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SHIP PROPULSION SHAFTING BEARING REACTION PROGRAMS MGE2 AND MGE--ETC(U)
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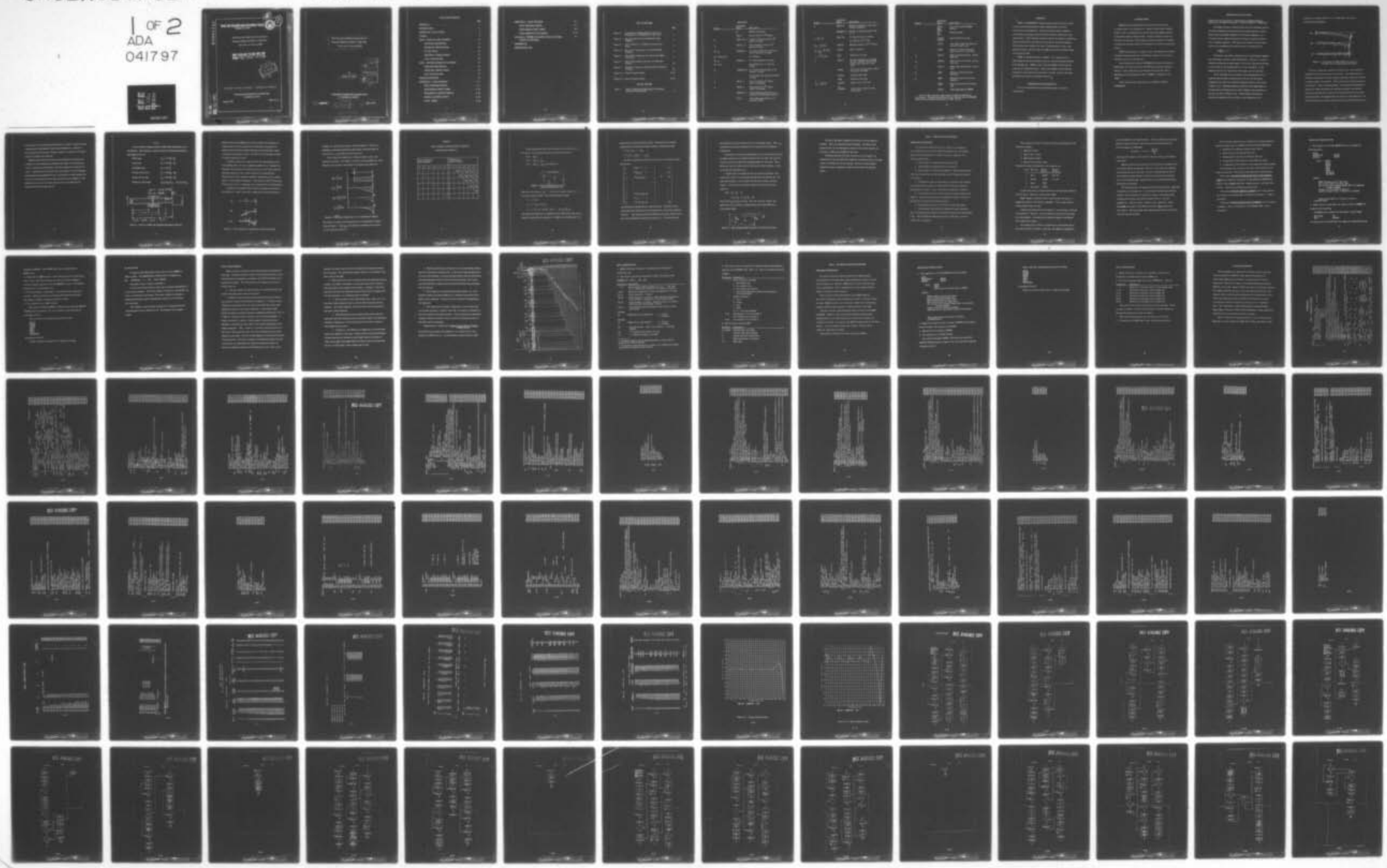

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
Washington, D.C. 20007

Ship Propulsion Shafting Bearing Reaction Programs MGE2 and MGE5 for IBM 7090 (with notes on Univac LARC)

APPLIED MATHEMATICS LABORATORY
TECHNICAL NOTE

August 1967 AML-70-67

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Ship Propulsion Shafting Bearing Reaction Programs MGE2 and MGE5 for IBM 7090 (with notes on Univac LARC).

by

10 Sharon E. Good

APPLIED MATHEMATICS LABORATORY

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NOTATION

Symbol	FORTRAN Name	Description
	N	Number of stations.
	NO (I)	Station number of I^{th} station.
x_i	DISTL (I), A	Length to extreme end from I^{th} station in inches.
d_a	DIA (I), B	Outer diameter of shaft at I^{th} station in inches.
(a) d_b	STIFX(I), C	(a) Inner (if hollow) or second (if sleeve) diameter in inches.
(b) Σ EI or ST		(b) Stiffness.
(a) d_c	WTS(I), D	(a) Third diameter in inches.
(b) Σ Aρ		(b) Weight in lb./in. per unit length.
W	CONWT(I), E	(a) Concentrated Weights in lbs. (negative in sign).
		(b) and Bearing reactions (positive in sign).
a	IM (I), I	Outer material at I^{th} station (only 1-5 possible).
b	JM (I), J	Inner material at I^{th} station (only 1-5 possible).
	IBRG(I), K	Code indicating presence (1) or absence (0) of bearing at station I.
	IS (I)	Code indicating sand (1) or no sand (0) in bore.

Symbol	FORTRAN Name	Description
E	YMAT, H	Moduli of elasticity in lbs.//sq. in. (Young's modulus).
ρ	DENMAT, P	Density of shaft materials in lbs./ cu. in.
$l_i = x_{i+1} - x_i$	DIST T(I)	(a) Section length in inches. (b) Stiffness (10^{-10}/EI)
$M_L = \int_0^L SdL$	BMTAB	Bending moment in 10^{-3} inch-lbs.
$\theta_L = \frac{1}{EI} \int_0^L MdL$	THETA	Slope in Radians.
$\delta_L = \int_0^L \theta_L \, dL$	DEF	Deflection in inches.
α	BNFLU	Influence numbers for bearings (lb. per .001-inch rise) and deflection and slope (for 1-inch rise).
	DIBRG	Section length from support point to extreme end table.
	IBTAB	Bearing index table.
n	IBRS	Number of bearings.
$S_L = \int_0^L WdL$	SFTAB	Shear force in 10^{-3} lbs.
	I2 IERROR	Error code in incorrect data preparation.

Symbol	FORTRAN Name	Description
	TITL2	Case title array for MGE2.
	IXM	Sentinel
	SWAT NS IYM	}Unused options.
R	CANOT CONOT	Bearing Reaction in lbs.
	WBAR	Total Shaft weight including concentrated loads in lbs.
	XBAR	Distance of Center-of-gravity from station no. 1 in inches.
A_a	AREA 1	Shaft cross section area, second material.
A_b	AREA 2	Shaft cross section area, second material.
A_c	AREA 3	Shaft cross section area, sand in bore.
I_a	AMI1	Moment of Inertia for first material.
I_b	AMI2	Moment if Inertia for second material.
	XBRG	Bearing relocation off straight line.
	TITL5	Case title array for MGE5.

Some storage areas have uses a and b in different sections of the program. The several arrays which have special names in READIN subroutine are listed as second entry in name column.

ABSTRACT

MGE2 is a FORTRAN IV program which computes characteristics of the main propulsion shaft of a ship, assuming that all bearing centers are on a straight line. Output from this program consists of the straight-line bearing reactions and the influence numbers for each support point. These influence numbers indicate the changes in supporting reactions produced by the raising or lowering of a particular bearing. The program also calculates the shear, bending moment, slope, and deflection values, and the weight and stiffness factors for stations designated along the shaft.

MGE5 is a program similar to MGE2. It is a design tool for determining the effects of bearing centers at any given elevation relative to the straight line. MGE5 is often used after MGE2 to determine the reactions of realigned bearings. Output from MGE5 includes bearing reactions at each support point and shear, bending moment, and slope and deflections values at designated stations.

ADMINISTRATIVE INFORMATION

The work reported herein was authorized under job number 1-890-202-01.

INTRODUCTION

MGE2 gives the characteristics of a shaft with all bearings, or support points, on a straight line. Output includes shear, bending moment, slope, and deflection as well as weight and stiffness factors at designated stations along the shaft. A table of influence numbers is listed for each bearing. These influence numbers indicate the changes in supporting reactions caused by the raising or lowering of a particular bearing.

MGE5 calculates shear, moment, slope, and deflection at various stations and bearing reactions, with bearing centers set in any given elevation relative to a straight line.

The programs were coded in FORTRAN IV with the exception of MAP double precision routines in the 7090 matrix inversion portion. Decks or further information are available from Code 830, Naval Ship Research and Development Center (NSRDC), Washington, D. C. 20007.

These programs have also been run on LARC and 7090 in FORTRAN II.

METHOD OF CALCULATION

(Taken from the "Calculation of Ship Propulsion Shafting Bearing Reactions on an IBM 650 Computer" written by Edward T. Antkowiak)

"Although the texts on indeterminate structures illustrate various devices for handling continuous beams on multiple supports, such as Hardy Cross or Relaxation Method, Three Moment Equations, etc., the large memory capacity and speed of a digital computer permits a more 'classical' approach. This approach is based on a direct evaluation of the relationship of the beam lead (w) to the deflection (δ).

$$EI \frac{d^4 \quad \delta}{dx^4} = W$$

"Therefore, successive integrations of the load-stiffness diagram will yield shear, moment, slope and deflection. However, in order to obtain zero deflection at each support, the correct reactions would have to be included in the load diagram prior to the integration. In the shafting problem, the reactions at each support are the unknowns.

"If the reactions are not included in the load diagram and it is assumed that the beam is held firmly at one end, the successive integrations will result in a deflection diagram similar to that shown in Figure 1 (a). Applying estimated reactions whose magnitudes are proportional to the deflection will yield a diagram with a smaller deflection, as shown in Figure 1 (b). Further approximations and sucessive integrations will converge to a zero deflection at the

supports, as shown in Figure 1 (c). At this point, the correct reaction has been applied.

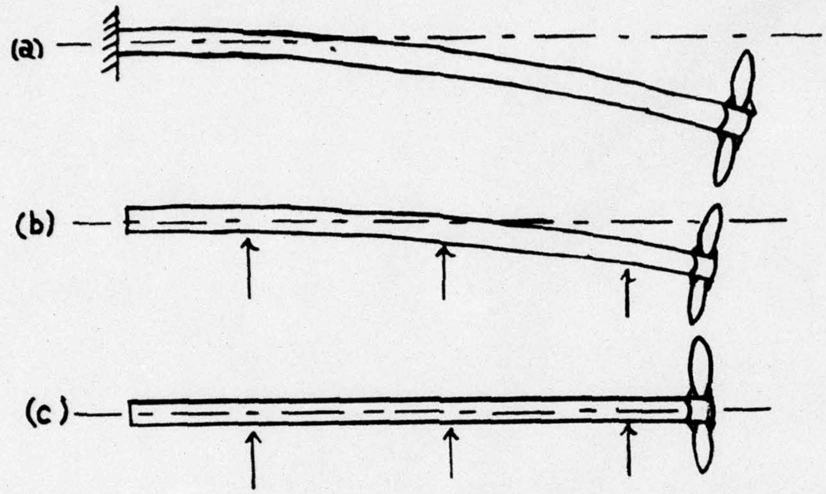


Figure 1 - Convergence of Shaft Deflection Curve to a Straight Line by Adding Support Reactions

"In order to apply this principle to practical use, some method of obtaining reaction estimates had to be devised. The method used is to determine the amount of reaction change produced by raising or lowering a bearing support a unit amount. This is also one of the final answers to our problem. These influence numbers are obtained by assuming the shaft has no weight and that a unit reaction is applied to one bearing. Successive integrations will then yield resulting deflections at all other bearing locations. By applying this unit reaction to each support in turn, a family of deflections will be obtained which can be substituted into a set

of equations (two more equations than there are number of support points), expressing the relationship of reactions and deflections. Solution of these equations will yield the 'influence numbers' necessary to the final solution of straight line reactions.

"Multiplying the influence numbers by the deflections obtained from integration of the unsupported, weighted (real) shaft, and summing the reaction changes for each bearing, the final straight line reactions will result. Applying this total reaction for each bearing to the load diagram and repeating the integration process, the deflection at each support will be zero, thus proving that the correct reaction has been applied. If the deflection is not zero, the entire process can be repeated until the bearing deflection becomes trivial."

THEORY

Figure 2 shows a sample section of shaft with nomenclature as in the Notation. The programs compute moment of inertia and weight per unit length as follows:

Outer area	$A_a = \pi/4\ (d_a^2 - d_b^2)$
Inner area	$A_b = \pi/4\ (d_b^2 - d_c^2)$
Innermost area	$A_c = \pi/4\ d_c^2$
Inertia of outer part	$I_a = \pi/64\ (d_a^4 - d_b^4)$
Inertia of inner part	$I_b = \pi/64\ (d_b^4 - d_c^4)$
Weight per unit length	$A_a\rho_a + A_b\rho_b + A_c\rho_c - (A_a + A_b + A_c)\rho_d$

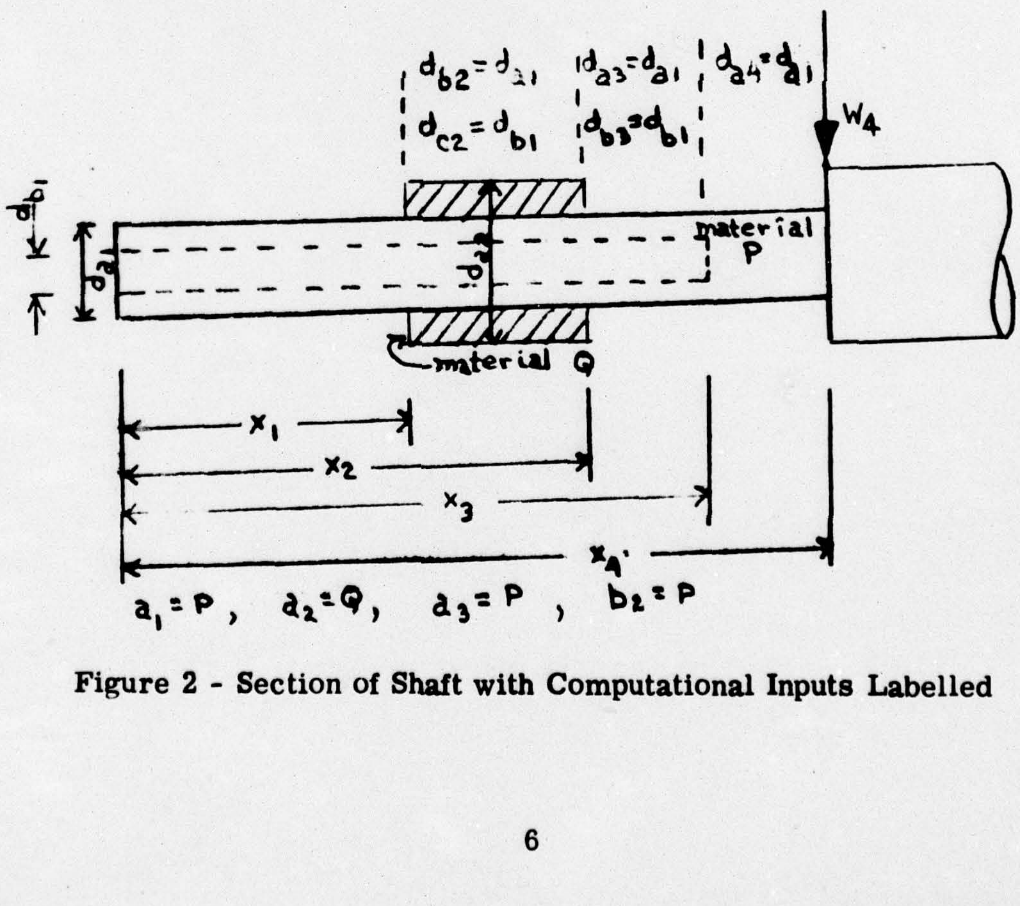


Figure 2 - Section of Shaft with Computational Inputs Labelled

where the first term (Material a) must be present in all cases; the second term (b) will be present for two materials; the third (c) is present only if the bore is filled with sand; and the fourth (d), which represents the upthrust of water, is present only if the shaft is wholly or partly immersed in water.

Consider a shaft of no weight but with the same stiffness as the real weighted shaft. If such a weightless shaft were on "straight line" bearings, there would be no reaction; however, if one of the bearings should be raised by 1 mil, forces would occur at each bearing. These forces are the "influence numbers" which form an n x n matrix where n is the number of bearings. The element in the i^{th} column and j^{th} row gives the force on Bearing i for a deflection of 1 mil at Bearing j.

Consider the weightless shaft acting as a cantilever as shown in (a) of Figure 3. When a unit force is applied at B, Section AB will be

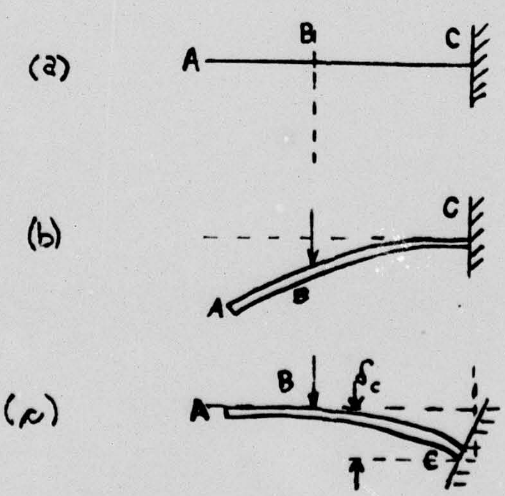


Figure 3 - Force Applied to a Weightless Cantilevered Beam

straight, but inclined at an angle to the horizontal (b). There is an advantage to assuming that Section AB remains horizontal with the wall moved (c), using AB as the reference axis.

Now consider the shear force, bending moment, slope, and deflection diagrams. According to the theory of beam deflection, these diagrams are related to one another by integration (see Figure 4).

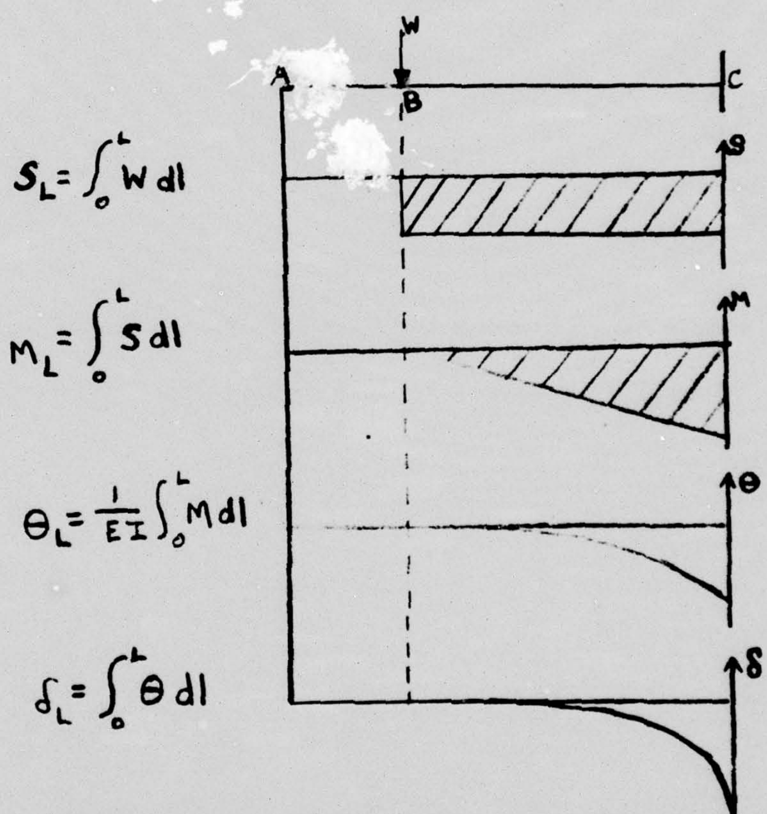


Figure 4 - Successive Integrations of a Load Stiffness Diagram

The result of a series of such integrations is summarized in tabular form by Table 1. Thus d_{24} is the deflection at Station 4 for a force of unity applied at Station 2.

TABLE I

Table of Deflections Resulting from Applying

Individual Unit Reactions

Force Applied at Station Number:						Deflection at Station Number:					
1	2	3	4	5	6	1	2	3	4	5	6
1							d_{12}	d_{13}	d_{14}	d_{15}	d_{16}
	1							d_{23}	d_{24}	d_{25}	d_{26}
		1							d_{34}	d_{35}	d_{36}
			1							d_{45}	d_{46}
				1							d_{56}
					1						

If the beam Section AB is not considered to be horizontal or at zero slope, these deflections must be corrected as follows:

At A: add Δ_o

At B: add $\Delta_o + \theta_o x_1$

At C: add $\Delta_o + \theta_o x_2$ (see Figure 5).

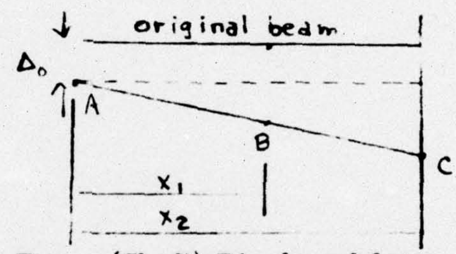


Figure 5 - **Beam (Shaft) Displaced from Horizontal Reference Line**

When unit reactions R_1, R_2, ... R_n occur at support points 1, 2, ... n along the weightless shaft, the following equations apply:

$$\delta_1 = \Delta_o + \theta_o x_1$$

$$\delta_2 = \Delta_o + \theta_o x_2 + d_{12} R_1$$

$$\delta_n = \Delta_o + \theta_o + x_n + d_{1n} R_1 + d_{2n} + \dots d_{(n-1)n} R_{(n-1)}$$

Two additional equations are required to solve this group; they may be found by considering the beam end C in Figure 5 as unfixed when it is

supported by reactions along its length. When acting as a multiply supported beam, this free end has no shear or moment, such that

$$0 = R_1 + R_2 + \dots + R_n$$

$$0 = x_1 R_1 + x_2 R_2 + \dots x_n R_n$$

All these equations can therefore be put into a n+2 equation square matrix form

$$\begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \cdot \\ \cdot \\ \cdot \\ \delta_n \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 1 & X_1 & 0 & 0 & 0 & \dots \\ 1 & X_2 & d_{12} & 0 & 0 & \dots \\ 1 & X_3 & d_{13} & d_{23} & 0 & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ 1 & X_n & d_{1n} & d_{2n} & d_{3n} & \dots \\ 0 & 0 & 1 & 1 & 1 & \dots \\ 0 & 0 & X_1 & X_2 & X_3 & \dots \end{bmatrix} \times \begin{bmatrix} \Delta_o \\ \theta_o \\ R_1 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ R_n \end{bmatrix}$$

representing the deflections for a given reaction. Inversion of this matrix gives the reactions for a given deflection, the reaction influence numbers. The columns which give deflection and slope condition now give slope and deflection influence numbers (i. e., the end slope and

the deflection for a given deflection at an intermediate point). Thus α_{32} represents the reaction at Support 3 for a theoretical unit deflection at Bearing 2.

Assuming the initial slope and deflection are zero and that reactions at support points are zero (shaft cantilevered at one end), the end shear (V_1) and end moment (M_1) of the weighted shaft are calculated. These results are used to modify the first (R_1) and last (R_n) reactions, so that V_1 and M_1 then approach zero.

Consider the actual shaft with only two external bearings, held at the end to ensure no initial slope and deflection (see Figure 6), with total shaft weight W, total moment from the other end M, and total length L. (The convention assumed is that all downward forces are negative.)

Then: $R_a + R_b = -W$

$$(L-x_1)\,R_a + (L-x_n)\,R_b = -M$$

from which R_a and R_b are found. The new moments, slopes, and deflections can be found by considering the real weight shaft with concentrated loads.

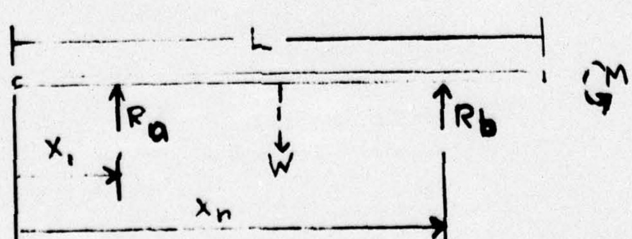


Figure 6 - Real Weighted Shaft with Only Two Bearings Present

The above discussion presents the solution to the two-bearing problem. Then, by using the influence numbers, the effect on the reactions when all the bearings are moved to the correct position can be found; Δ_o and θ_o are modified at this time.

The actual answers from the inversion will not be exact, but repeated entry into the deflection integration routines will give corrected values of the deflection for all bearings. Several of these weighted integrations may be required to obtain results within the required margin.

PROGRAM DESCRIPTION

To calculate the characteristics of a shaft with all supports on a straight line as outlined in "Method of Calculation," the shafting system must be divided into a number of stations, subject to the following restrictions:

1. Total number of stations must not exceed 400.

2. Total number of supports must not exceed 22.

3. Each change in cross-section diameter, each bearing location, each concentrated load, and the beginning of each immersion requires a new station.

4. Although the length of each station is arbitrary, there should be enough of these stations to provide sufficient abscissa points for plotting shear, moment, slope, and deflection diagrams, if desired.

5. All stations (except the last) must have nonzero diameter and material. The last data card is not considered a section; it serves to specify the total length of the shafting system.

6. Bearing may not occur at the first or at the last station.

7. Concentrated loads should not appear at bearing locations since calculated bearing-reaction values will overwrite the concentrated loads. Add an additional shaft section with a 0.100-inch, or even a 0.0001-inch, separation.

The program is written in a general manner and provides for the following variables:

1. Material of shaft
2. Shaft in air or water
3. Shaft solid or hollow
4. Sand in bore of hollow shaft

The specific moduli and densities in the program are:

Code	Material	Density (lb/cu in.)	Modulus (lb/sq in.)
1	Steel	-.28355	30×10^6
2	Bronze	-.31399	15×10^6
6	Sand	-.0636	
7	Salt water	-.03705	

If materials used in a specific shaft have constants quite different from the above, additional values may be added.

Slight changes in diameter may be ignored when the effect on weight and stiffness of the shaft is negligible. The average diameter of the propeller taper is used.

Loads acting downward will be negative. In most cases, reactions will be positive. However, in some instances where several bearings are close together, one bearing may indicate a negative reaction for the straight-line condition.

The weight of the propeller is applied as a concentrated load at its center of gravity, if known; otherwise, the weight is considered to

act at the middle of the tapered section. The dry weight of an immersed propeller may be reduced to take into account the buoyant effect of water by using the relationship

$$W\text{ (water)} = W\text{ (air)} * \frac{D_p - D_w}{D_p}$$

where D_p is the density of the propeller material and D_w is the density of the water.

Bearing reactions are assumed to act at points in the middle of the fore and aft ends of the bearings. However, in the case of a relatively long bearing such as a stern tube, it may be assumed that the load is concentrated one shaft diameter forward of the aft end of the bearing. For a more detailed study, support points at several positions along a bearing may be assumed.

The program gives the magnitude of all bearing reactions, assuming all bearings on a straight line. It prints slope and deflection influence numbers, which represent the amount of change in all bearing loads resulting from raising a particular bearing 0.001 in. from the straight line. Values of shear, moment, slope, delfection, weight (in pounds per inches), and stiffness (in terms of $\frac{1}{EI}$) are given for each station. The total weight of the shaft and the location of the center of gravity are also printed.

The criteria for determining zero deflection at a bearing and the absence of shear force or moment at the free end are listed below:

1. Deflection at a bearing no greater than 0.001 in.
2. Shear force at free end less than 10 lb.
3. Bending moment at free end less than 100 in.-lb.
4. A maximum of four iterations on the deflection check.
5. A maximum of four iterations on the shear and moment checks.

The following error printouts occur after unrecoverable errors have been detected. The program then transfers to next data case.

The printout TOO MANY ITERATIONS DEFL XXXX MOMENT XXXX occurs when four iterations through DEFLN and BEAM have failed to meet terminal deflection, bending moment, and shear force criteria. The current results are then accepted.

The printout STATION DISTANCE ERROR occurs when stations are not input in ascending order of distance from Station 1. Case is terminated.

The printout SINGULAR INFLUENCE NUMBERS occurs if matrix is singular. Since it is indicative of incompatible data, case is terminated.

OPERATING INSTRUCTIONS

1. The program run with 7090 IBSYS Version 13 includes the following cards:

$JOB	
$EXECUTE	IBJOB
$IBJOB	FIOCS

decks MGE2
RED2
BEAM
DEFL
INOU
INFN
AM MAT2
AM DPAF

$DATA

MGE2 heading card for input case 1
One card per station for input case 1
One card for each constant change (omit if no material constant changes)
Sentinel card with punch in column 2
Additional cases of data, if called for by sentinel
.
.
.
Final sentinel has 9- or 7-punch in column 2

$\frac{7}{8}$ END OF FILE

2. Output of five or more pages per case is written on SYSOU1 for program control printing.

At NSRDC, when compiled with plot option, control cards

$ATTACH	B9
$AS	SYSLB4

are inserted before $ EXECUTE card, and plots for SC 4020 may be

prepared on SYSLB4. Deck GRAP must also be included before $DATA card.

3. Total time for IBSYS compile, load, and execute of six varied cases was 1.8 min. Since the load time for retrieval of binary program deck from master instruction reel with $IEDIT is 1 min, it is obviously advantageous to run multiple cases.

4. No sense switches, sense lights, or scratch files are used by the program. Memory requirement (including I/O subroutines) 19,400. For smaller computer, dimensions could be revised.

5. The program run on LARC includes:

Data cards for Program MGE2, followed by six cards with END OF TAPE punched in columns 1-12, are converted to tape and ready for mounting on Unit 11.

Object code tape containing instructions for routine

MGE2
READ2
BEAM
DEFL
INOU
INFN
AM MAT2L

is mounted on Unit 13.

Output is written on Tape 20 for 1/1 LSC loop printing.

SC 4020 PLOTS

An option for SC 4020 graphic output may be used at NSRDC on 7090 or LARC. Card MGE2 0164 (or MGE5 0119) is changed from

981 CONTINUE to 981 CALL GRAPH

The graph routine is listed in Appendix A.

The two sets of plots made for each case are moment and deflection versus station distance. If the total number of stations is less than 99, one frame is produced for each graph. For larger numbers of stations, a fixed station distance scale of 450 ft/frame results in 2 to 21 frames for each graph.

The ordinate versus abscissa is plotted as a continuous line with bearing stations further identified by X. See Appendix A for sample output.

SHAFT ARRANGEMENT

Figure 7 shows a typical line shaft dimensioned for preparation of input data. The sketch should be made to some appropriate scale, using information from arrangement, assembly, and detailed drawings of low speed gear and shaft. The relationship of the components can then be readily observed.

1. The total number of stations must not exceed 400 and the total number of support points must not exceed 22.

2. Station 1 is the forward end of the shaft and all other stations are located in terms of their distance from Station 1. A station must be initiated at each support point, at each concentrated load, and at each significant change in cross-section diameter. Concentrated loads should not appear at bearing locations; an additional station with 0.001- or 0.0001-in. separation may be used (see note at end of paragraph). To reduce the number of stations, slight changes in diameters may be ignored or combined when their effect on the weight and stiffness of the shaft is negligible. Thus, in Figure 7, since the journal sections were only 1/4 in. wider than the shaft, they were considered to be the same diameter as the shaft. Also the average diameter of the tapered propeller section was used. Note that, if desired, the additional weight of journal sections may be compensated for without increasing the number of stations by adding the weight as concentrated load at the center of the

bearing, but such a load would not be included in the bearing reactions given as output. All concentrated weights, however, are included in the total weight of the shaft.

3. Where the thrust collar is forward of the low speed gear and not integral, its weight is treated as a concentrated load, since it does not add significantly to the stiffness of the system. In Figure 7, the thrust bearing is aft of the low speed gear and the thrust collar is integral with the shaft; therefore, it is treated as part of the shaft.

4. a. Since the gear is not a solid section (rim, webs, etc.), an equivalent outside diameter must be used to obtain its proper lateral stiffness. The outside diameter of the hub section may be used as the equivalent outside diameter.

b. The difference between the total weight of the actual low speed gear and shaft assembly and the calculated weight of the equivalent assembly is applied as a concentrated load on this section so that the total weight will be correct.

c. In Figure 7, this difference is applied as one concentrated load at the centerline of the gear, midway between fore and aft bearings. Present practice is to divide the concentrated load by the number of webs, and to apply these equal loads at the points where the webs meet the hub. In most cases, either method may be used.

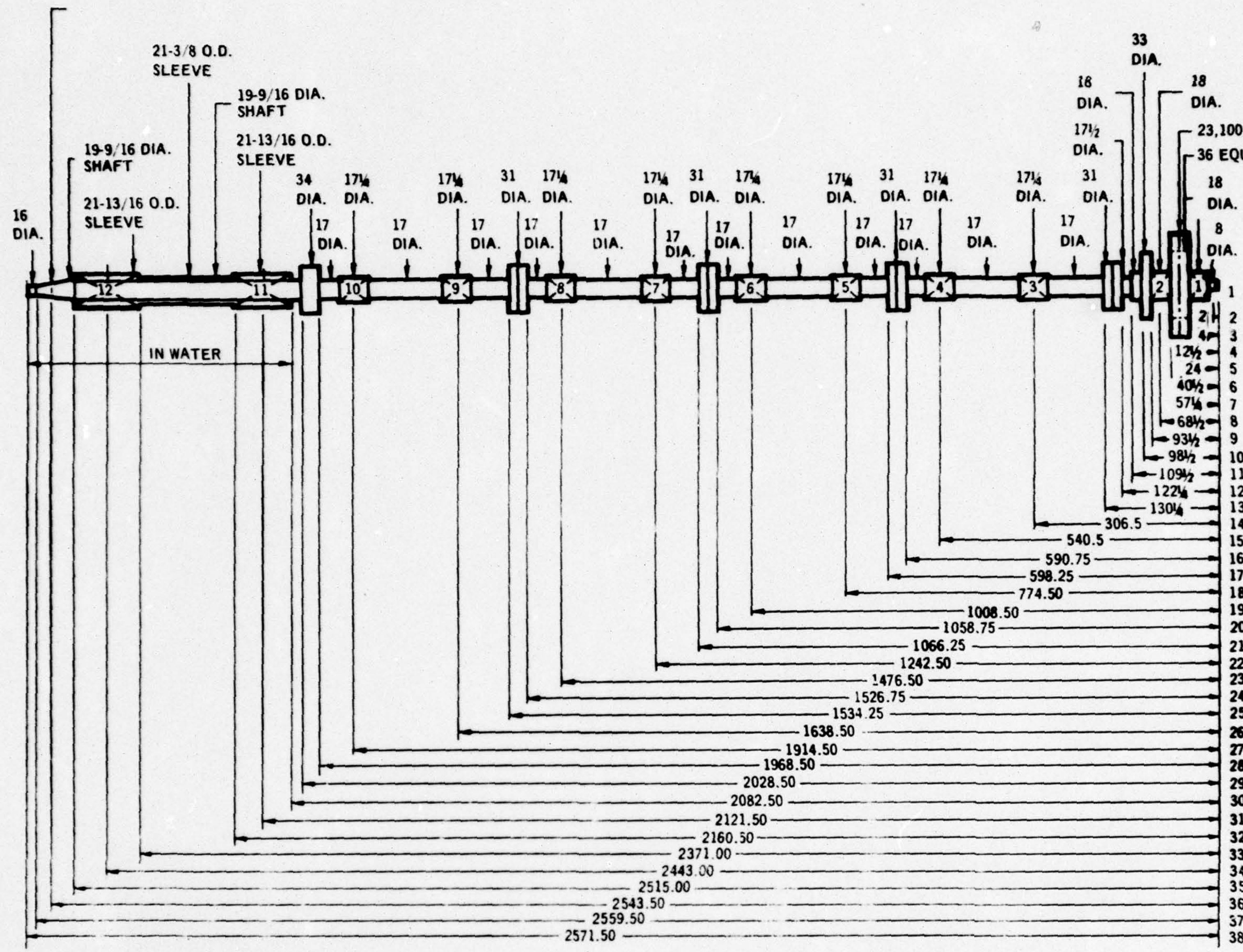
5. Bearing reactions are assumed to act at points midway between the fore and aft ends of each bearing. In the case of long bearings (such as a stern tube bearing), it may be assumed that the load is concentrated one shaft diameter forward of the aft end of the bearing. For a more exact detailed study, support points at several positions along a bearing may be assumed.

6. If the shaft is to be studied with the ship waterborne, a note should be made on the sketch (Figure 7) to indicate what portion of the shaft is to be immersed. A station must be initiated at the beginning of the immersion.

7. The weight of the propeller is applied as a concentrated load at its center of gravity, if known; otherwise, the weight is considered to act at the middle of the tapered section. The dry weight of an immersed propeller should be reduced to take into account the buoyancy effect of salt water by the relationship

$$\text{Weight (water)} = \text{Weight (air)} \times \frac{(\text{Density (prop)} - \text{Density (water)})}{\text{Density (prop)}}$$

For bronze with a density of 0.31399 lb/cu in. and salt water with a density of 0.03705 lb/cu in., the multiplicative factor would be 0.882.



TOTAL WT. OF U.S. GEAR & SHAFT - 40,500 LBS. SHAFT ONLY - 11,050 LBS. ESTIMATED EQUIV. DIA. OF HUB FOR LATERAL STIFFNESS 36 O.D.

Figure 7 – Shafting Arrangement Dimensioned for Computer Program

DATA PREPARATION

1. MGE2 Title Card: Columns 1-72 alphanumeric information to identify the case.

2. One card for each station (maximum of 400) in accordance with FORMAT (I3, 5F12.4, 2I2, 2I1).

Column No.	Explanation	
1-3	Station number right justified (ΔΔ1, ΔΔ2, . . . , 105, 106, etc.). Last station must have 9 in column 1 as sentinel.	
*4-15	Distance of beginning of station from Station 1, in inches.	
*16-27	Outer diameters, in inches.	
*28-39	Second diameter, in inches. Inner diameters of bushing or sleeve if used, or diameters or bore if hollow shaft.	
*40-51	Third diameter, in inches. Diameter of bore in a hollow shaft which also has bushing or sleeve.	
*52-63	Concentrated weight (if present) minus values for downward weight.	
64 blank		
65	**Material of outer diameters	{ 1, if steel 2, if bronze
66 blank		
67	**Material of inner diameter	{ 1, if steel 2, if bronze
68	Bearing position - blank, if no support; 1, if bearing present.	
69	1, if shaft in water; blank, if in air.	
70	1, if sand bore; blank, if no sand.	

---

* The above numbers may be punched anywhere in field, and the decimal point must be punched.

** If material is other than steel or bronze, new constants for density and modulus of elasticity must be given.

3. One card for each new material or change of density and modulus of elasticity using FORMAT (2I2, 2F12, 2). (Omit if no material constant changes.)

Column No.	Explanation
2	Code for action to be taken:
	1 - new density only
	2 - new modulus only
	3 - new density and modulus
	4 - set to punch influence numbers (not activated in current program)
4	Code for material:
	1 - steel
	2 - bronze
	6 - sand
	7 - water
	3, 4, 5 - for new materials
5-16	New density if 1 or 3 in column 2
	New modulus if 2 in column 2
17-28	New modulus if 3 in column 2

4. End of Case sentinel card (I2).

Column 2	Explanation
0 or blank	End last case, no graphs.
7	End last case after graphing
8	Graph, then more cases follow.
9	More cases follow, no graphs.
5, 6	Same as 0.

MEG5 - BEARINGS RAISED OR LOWERED

PROGRAM DESCRIPTION

The table of influence numbers obtained from MGE2 enables the calculation of reactions when certain bearings are moved vertically off the straight line. However, MGE5 must be used to find the shear force, being moment, slope, and deflection at each station caused by raising or lowering certain bearings.

When a study of shaft characteristics from MGE2 suggests that a better alignment could be achieved by raising or lowering certain bearings, MGE5 should be run to determine whether the repositioning imposes excessive shear forces or bending moments on the shaft.

The same general computational procedure is used for both MGE5 and MGE2. However, since the influence numbers and weight and stiffness factors of the shaft system are not affected by changing the elevation of bearings, the output of this MGE5 program does not list these factors, It gives instead a single page of shear, moment, slope, deflection, and bearing reactions.

Restrictions on input are the same as those for MGE2.

OPERATING INSTRUCTIONS

1. The program run with 7090 IBSYS Version 13 includes:

$JOB
$EXECUTE IBJOB
$IBJOB FIOCS

decks MGE5
RED5
Beam and rest of decks same as MGE2

$DATA

MGE5 heading card for input case 1
One to give bearing change cards
MGE2 heading card for input case 1
One card per station for input case 1
One card for each constant change (omit if no material constant changes)
Sentinel card with column 2 punched
Additional sets of input data if called for by sentinel
.
.
.
Final sentinel has 9-or 7-punch in column 2.
$\frac{7}{8}$ END OF FILE

2. Output of one page per case is written on SYSOU1 for program control printing. Plot option is as in MGE2.

3. Execution time is similar to MGE2.

4. The program run on LARC includes:

Data cards for Program MGE5, followed by six cards with END OF TAPE punched in columns 1-12, are converted to tape for mounting on Unit 11.

Object code tape containing instructions for routines

MGE5
READ5
BEAM
DEFL
INOU
INFN
AM MAT2L

is mounted on Unit 13.

Output is written on Tape 20 for 1/1 LSC loop printing.

DATA PREPARATION

1. MGE5 Title Card: Columns 1-72 alphamaric information to identify how case differs from similar MGE2 run.

2. One to five bearing change cards using FORMAT (I1, 5F11.8).

Column No.	Explanation
1	Blank or 0, if not last card; 9, if last change card.
2-12	Relocation of bearing 1 from straight line.
13-23	Relocation of bearing 2 from straight line.
24-34	Relocation of bearing 3 from straight line.
35-45	Relocation of bearing 4 from straight line.
46-56	Relocation of bearing 5 from straight line.

Next card would contain relocation for next five bearings. Values are given in inches; location of bearing may be punched anywhere in field and the decimal point must be punched.

Plus value is bearing above the line; minus value is below.

3. A complete set of MGE2 input cards, including case sentinel.

ACKNOWLEDGMENTS

These programs are adaptations of shafting systems programs written originally for IBM 650 by Mr. Edward Antkowiak of the Boston Naval Shipyard; his assistance in preparing this version is appreciated. Much of the coding of an expanded shafting program for IBM 704, done by Mr. Edgar H. Sibley and others at the General Electric Lynn Digital Computer Section, is included within this program. Mr. Ralph E. Wolfe of the Boston Naval Shipyard contributed greatly to the theorectical approach to this calculation and orignated the concept of obtaining the influence numbers by integration of a "weightless" shaft. Mr. Frank Zaher of Naval Ship Systems Command and Mr. Edward Ryan, formerly of New York Naval Shipyard, made suggestions which have been incorporated in the final program.

Other versions of the shafting program, written at Boston Naval Shipyard, are also available for IBM 1620 and Burroughs Datatron 205.

APPENDIX A

MGE2 - PROGRAM LISTING

```
$IBFTC MGE2     DECK                                                     MGE20001
C       SHAFTING BEARING REACTIONS  MGE2                                 MGE20002
C       S. GOOD    DAVID TAYLOR MODEL BASIN    MAY,1963                  MGE20003
C       STRAIGHT LINE BEARING REACTIONS                                  MGE20004
C       IDENTIFY MATERIALS ...STEEL...1                                  MGE20005
C                             BRONZE..2                                  MGE20006
C                             SAND....6                                  MGE20007
C                             WATER....7                                 MGE20008
        DIMENSION D!STL(401),DIA(401),STIFX(401),WTS(401),CONWT(401),    MGE20009
      1IM(401),JM(401),IBRG(401),IWATR(401),IS(401),YMAT(7),DENMAT(7),   MGE20010
      2DISTT(401), BMTAB(1620),THETA(802),DEF(401),BNFLU(25,25),DIBRG(25)MGE20011
      3,IBTAB(25), SFTAB(1620),TITL2(12),NO(400)                         MGE20012
       COMMON N,NO,DISTL,DIA,STIFX,WTS,CONWT,IM,JM,IBRG,                 MGE20013
      1 IWATR,IS,YMAT,DENMAT,DISTT,BMTAB,THETA,DEF,BNFLU,DIBRG,IBTAB,    MGE20014
      2  IBRS,SFTAB,I2,IERROR,       TITL2,IXM                           MGE20015
       DIMENSION CANOT(401),CONOT(25)                                    MGE20016
       DIMENSION NS(50)                                                  MGE20017
       COMMON SWAT,NS,IYM                                                MGE20018
    1  FORMAT(12A6)                                                      MGE20019
24     FORMAT(  /14X,         84H  BEARING  REACTION  INFLUENCE  NUMBERSMGE20020
      1  (LB.  PER  0.001  INCH  RISE  OF  BEARING) //)                  MGE20021
200    FORMAT(I4,11F10.1)                                                MGE20022
  203  FORMAT(///7H  BRG.  /115H  NO.     1        2        3            MGE20023
      1 4        5        6        7        8        9        10         MGE20024
      2   11       //)                                                   MGE20025
  205  FORMAT(///7H  BRG.  /115H  NO.    12       13       14            MGE20026
      115        16       17       18       19       20       21         MGE20027
      2   22       //)                                                   MGE20028
20     FORMAT(115H  STATION    SECTION       FIRST       SECOND          MGE20029
      1THIRD      CONCENTRATED   MATERIALS   BEARING    IN    WITH /     MGE20030
      2       115H     NO.     DISTANCE     DIAMETER     DIAMETER       DMGE20031
      1IAMETER       WEIGHT                 POSITION  WATER  SAND /      MGE20032
      4       115H              (INCH)       (INCH)       (INCH)         MGE20033
      1(INCH)       (LB.)        A      B                      //)       MGE20034
 1000  FORMAT(111H0         DEFLECTION  AND  SLOPE  INFLUENCE  NUMBERS  OMGE20035
      IN  STATION  1  (FOR  ONE  INCH  OF  RISE  OF  BEARING)  //95H     MGE20036
```

```
     2                                BRG.NO.                        DEFLECTION       MGE20037
     3                   SLOPE    )                                                   MGE20038
 1010 FORMAT(I35,F30.7,F30.8)                                                         MGE20039
1030  FORMAT(1H120X,12A6///)                                                          MGE20040
1031  FORMAT(/////40X,35H  SHAFTING   SECTION   INTEGRALS     //                      MGE20041
     1         110H      STATION        SHEAR FORCE              MOMENT               MGE20042
     1         SLOPE                DEFLECTION             BEARING  /                 MGE20043
     2         113H         NO.              (KIP.)              (KIP.INCH)           MGE20044
     1      (RADIANS)               (INCH)           REACTION (LBS.)        )         MGE20045
 1032 FORMAT(//    40X,44H  SHAFTING  WEIGHT   AND   STIFFNESS  FACTORS //            MGE20046
     1         110H      STATION             SECTION             WEIGHT               MGE20047
     1  STIFFNESS(1/EI)      CONCENTRATED WEIGHT       BEARING  /                     MGE20048
     4         111H         NO.          DISTANCE(INCH)          (LB/IN.)             MGE20049
     1 (X0.000000000001)      OR REACTION (LB.)       POSITION  //)                   MGE20050
 1035 FORMAT( /// 40X,44H  STRAIGHT  LINE  BEARING  REACTIONS  (LBS.)                 MGE20051
     1 //     F14.1,10F10.1 )                                                         MGE20052
 1036 FORMAT(1H1 40X, 42H ***  SHAFTING  SYSTEM  PROGRAM  MGE2  *** ///               MGE20053
     1         20X,12A6///52X,14H  INPUT  DATA   //)                                  MGE20054
 1037 FORMAT(F14.1,10F10.1       )                                                    MGE20055
1038  FORMAT(///  8X,     70HTOTAL      SHAFT      WEIGHT     (INCLUDING  COMGE20056
     1NCENTRATED  LOADS)      =     F11.2,7H    LB.     /                             MGE20057
     2          /80H           DISTANCE    OF    CENTER    OF    GRAVITY    FROMMGE20058
     3    STATION    NO.    1    =     F10.4,7H    INCH )                              MGE20059
1050  FORMAT(I9,-3PF21.5,F19.3,0PF20.7,F20.7,F18.1)                                   MGE20060
1090  FORMAT(I9,F20.4,F20.4,    F20.6,  F20.2,I16)                                    MGE20061
C       DENSITY AND MODULUS FOR STEEL, BRONZE                                         MGE20062
 1221 YMAT(1)=30000000.0                                                              MGE20063
      YMAT(2)=    15000000.0                                                          MGE20064
      DENMAT(1)=-0.28355                                                              MGE20065
      DENMAT(2)=-0.31399                                                              MGE20066
C     CLEAR STORAGES TO ZERO INITIALLY                                                MGE20067
      DO 2001 ISET=1,25                                                               MGE20068
      DO 2000 JSET = 1,25                                                             MGE20069
 2000   BNFLU(JSET,ISET) = 0.0                                                        MGE20070
 2001     CONOT(ISET) = 0.0                                                           MGE20071
      DO 2003 ISET=1,1620                                                             MGE20072
```

```
      BMTAB(ISET)=C.0                                                  MGE20073
 2003 SFTAB(ISET)=C.0                                                  MGE20074
      DO 2004 ISET=1,401                                               MGE20075
 2004 CANOT(ISET)=0.0                                                  MGE20076
      NIB=1                                                            MGE20077
      IERROR = 1                                                       MGE20078
       READ (5,1) TITL2                                                MGE20079
      WRITE (6,1036) TITL2                                             MGE20080
      WRITE (6,20)                                                     MGE20081
      CALL READIN                                                      MGE20082
      IF(IERROR-1) 57,57,560                                           MGE20083
   57 CALL INFNOS                                                      MGE20084
   62 WRITE(6,1030) TITL2                                              MGE20085
      CALL INOUT                                                       MGE20086
      WRITE(6,1000)                                                    MGE20087
      WRITE(6,1010)(NO(J),(BNFLU(JA,J),JA=24,25),J=1,IBRS)             MGE20088
      IF(IERROR-1) 65,65,560                                           MGE20089
   65 CALL DEFLN                                                       MGE20090
      I2=4*N+4                                                         MGE20091
      WBAR=SFTAB(I2)                                                   MGE20092
      XBAR= DISTL(N+1) -BMTAB(I2)/SFTAB(I2)                            MGE20093
       CALL BEAM                                                       MGE20094
      CALL DEFLN                                                       MGE20095
      K=N+1                                                            MGE20096
  230 WRITE(6,1030) TITL2                                              MGE20097
       WRITE(6,24)                                                     MGE20098
       KTEST = 0                                                       MGE20099
      KTES2=0                                                          MGE20100
210   DO 300 I1=1,IBRS                                                 MGE20101
      IBSR=IBTAB(I1)                                                   MGE20102
      DO 250 I3=1,IBRS                                                 MGE20103
      IASR=IBTAB(I3)                                                   MGE20104
250   CONWT(IBSR)=DEF(IASR)*BNFLU(I1,I3)*(-1000.0) +CONWT(IBSR)        MGE20105
      THETA(1)=  THETA(1)-(DEF(IBSR)*BNFLU(25,I1) )                    MGE20106
300   DEF(1) =DEF(1) - ( DEF(IBSR)* BNFLU(24,I1) )                     MGE20107
 979  CALL DEFLN                                                       MGE20108
```

```
      DO 400 I=1,IBRS                                                    MGE20109
      J=IBTAB(I)                                                         MGE20110
      IF(ABS (DEF(J))- .001)400,400,445                                  MGE20111
400   CONTINUE                                                           MGE20112
      IF(KTEST-4) 410, 450, 450                                          MGE20113
  410 IF(ABS(BMTAB(I2))-100.)420,222,222                                 MGE20114
  420 IF(ABS(SFTAB(I2))-10.)500,222,222                                  MGE20115
 222  KTEST = KTEST +1                                                   MGE20116
      CALL BEAM                                                          MGE20117
      GO TO 979                                                          MGE20118
  445 KTES2=KTES2+1                                                      MGE20119
      IF (KTES2-4) 210, 450, 450                                         MGE20120
  450 WRITE(6,451) KTES2,KTEST                                           MGE20121
  451 FORMAT(27HOTOO MANY ITERATIONS - DEFL  I4,  9H  MOMENT  I4)        MGE20122
500   DO 515 I=1,K                                                       MGE20123
      DISTT(I)=   0.0                                                    MGE20124
      IF (STIFX(I))515,515,514                                           MGE20125
514   DISTT(I)=1.E12/STIFX(I)                                            MGE20126
515   CONTINUE                                                           MGE20127
800   DO 825 I=1,IBRS                                                    MGE20128
      J=IBTAB(I)                                                         MGE20129
820   CONOT(I)=CONWT(J)                                                  MGE20130
825   CANOT(J)=CONOT(I)                                                  MGE20131
      IF(IBRS-11)  350,350,351                                           MGE20132
 350   K2 =IBRS                                                          MGE20133
      GO TO 310                                                          MGE20134
 351   K2 = 11                                                           MGE20135
310   CONTINUE                                                           MGE20136
  320 WRITE(6,203)                                                       MGE20137
      DO 322 J=1,IBRS                                                    MGE20138
  322 WRITE(6,200)NO(J),(BNFLU(I,J),        I=1,K2)                      MGE20139
      WRITE (6,1035)                                                     MGE20140
      WRITE (6,1037) (CONOT(I),I=1,K2)                                   MGE20141
352   IF(IBRS-11)517,517,357                                             MGE20142
  357 WRITE (6,205)                                                      MGE20143
      DO 358 J=1,IBRS                                                    MGE20144
```

```
  358 WRITE (6,200) NO(J),(BNFLU(I,J),I=12,IBRS)                    MGE20145
        WRITE (6,1035)                                               MGE20146
      WRITE(6,1037) (CONOT(I),I=12,IBRS)                             MGE20147
 517   CONTINUE                                                      MGE20148
  540 WRITE(6,1030) TITL2                                            MGE20149
      WRITE (6,1031)                                                 MGE20150
      DO 545 I=1,K                                                   MGE20151
      IB = I+I                                                       MGE20152
      IA = IB+IB                                                     MGE20153
  545 WRITE(6,1050) NO(I),SFTAB(IA),BMTAB(IA),THETA(IB-1),DEF(I),    MGE20154
     1 CANOT(I)                                                      MGE20155
      WRITE (6,1030) TITL2                                           MGE20156
       WRITE(6,1032)                                                 MGE20157
  547 WRITE(6,1090) (NO(I),DISTL(I),WTS(I),DISTT(I),CONWT(I),IBRG(I),MGE20158
     1I=1,K)                                                         MGE20159
      WRITE(6,1038) WBAR,XBAR                                        MGE20160
      IXM = IXM                                                      MGE20161
      IF(IXM)1222,1222,980                                           MGE20162
 980  GO TO(1222,1222,1222,1222,1222,1222,981,981,1221),IXM          MGE20163
  981 CALL GRAPH                                                     MGE20164
 560  IF(IXM-7)1222,1222,1221                                        MGE20165
1222  CONTINUE                                                       MGE20166
      WRITE(6,1036)                                                  MGE20167
       STOP                                                          MGE20168
      END                                                            MGE20169
```

```
$IBFTC RED2     DECK                                                    RED20002
C    READIN MGE2                                                        RED20003
      SUBROUTINE READIN                                                 RED20004
C        KEY FOR IXM SENTINEL                                           RED20005
C      BLANK  ,0  SINGLE CASE, LAST CASE - NO PLOT                      RED20006
C     IXM -  1   NEW DENSITY                                            RED20007
C            2   NEW MODULUS                                            RED20008
C            3   NEW DENSITY AND MODULUS                                RED20009
C            4   MULTIPLE WT RUN - SPEC CASE                            RED20010
C            5,6   SAME AS ,0                                           RED20011
C            7   PLOT SINGLE CASE                                       RED20012
C            8   PLOT THEN MULTIPLE CASES                               RED20013
C            9   MULTIPLE CASES - ANOTHER FOLLOWS - NO PLOT             RED20014
C      VARIABLE NAMES USED IN READIN DO NOT MATCH REST OF PROGRAM
       DIMENSION A(401), B(401),C(401),D(401),E(401),I(401),J(401),     RED20016
     1K(401),L(401),IS(401),H(  7),P(  7),DISTT(401),BMTAB(1620),       RED20017
     2THETA(802),DEF(401),BNFLU(25,25),DIBRG(25),IBTAB(25),SFTAB(1620), RED20018
     3TITL2(12)   ,NO(400)                                              RED20019
      COMMON N,NO,A,B,C,D,E,I,J,K,L,IS,H,P,DISTT,BMTAB,THETA,DEF,       RED20020
     1BNFLU,DIBRG,IBTAB,                                                RED20021
     2  IBRS,SFTAB,I2,IERROR,        TITL2,IXM                          RED20022
      DIMENSION NS(50)                                                  RED20023
      COMMON SWAT,NS,IYM                                                RED20024
   10 FORMAT(    I3,5F12.4,2I2,3I1)                                     RED20025
 15   FORMAT (2I2,2F12.2)                                               RED20026
20    FORMAT(I7,4F14.4,F14.2,2I6,I8,I9,I6)                              RED20027
  90   FORMAT(25H0 STATION DISTANCE ERROR      I5)                      RED20028
 91   FORMAT(24I3)                                                      RED20029
      P(6)=-0.0636                                                      RED20030
      P(7)=-0.03705                                                     RED20031
      DO 40 N=1,400                                                     RED20032
   22 READ(5,10)NO(N),A(N),B(N),C(N),D(N),E(N),I(N),J(N),K(N),L(N),IS(N)RED20033
      IF(NO(N)-900)40,40,45                                             RED20034
 40   CONTINUE                                                          RED20035
   45  NO(N) = NO(N) -900                                               RED20036
   51 WRITE(6,20)(NO(I1),A(I1),B(I1),C(I1),D(I1),E(I1),I(I1),           RED20037
```

```
      1J(I1),K(I1),L(I1),IS(I1),I1=1,N)                               RED20038
55    PI=3.14159265                                                   RED20039
       N = N-1                                                        RED20040
 24   READ (5,15) IXM,IYM,AVIT,DAVIT                                  RED20041
      IF(IXM) 36,36,27                                                RED20042
 27   GO TO (29,25,28,81,36,36,36,36,36),IXM                          RED20043
 28   H(IYM)=DAVIT                                                    RED20044
 29   P(IYM)=AVIT                                                     RED20045
      GO TO 24                                                        RED20046
 25   H(IYM)=AVIT                                                     RED20047
      GO TO 24                                                        RED20048
 81   SWAT=AVIT                                                       RED20049
C     READ (5,91) (NS(I3),I3=1,IYM)     OPTION NOT ALLOWED IN CURRENT RED20050
 36   DO 79 I3=1,N                                                    RED20051
      DISTT(I3)=(A(I3+1)-A(I3))*.25                                   RED20052
      IF(DISTT(I3))82,56,56                                           RED20053
   82 WRITE(6,90)NO(I3)                                               RED20054
       IERROR = 2                                                     RED20055
       GO TO 80                                                       RED20056
56    AREA1=PI*(B(I3)**2-C(I3)**2)/4.0                                RED20057
63    AMI1=PI*(B(I3)**4-C(I3)**4)/64.0                                RED20058
      IMAT=I(I3)                                                      RED20059
      WT1=AREA1*P(IMAT)                                               RED20060
      STIF1=H(IMAT)*AMI1                                              RED20061
      ST=STIF1                                                        RED20062
      WAIT=WT1                                                        RED20063
      IF(J(I3))65,66,65                                               RED20064
65    AREA2=PI*(C(I3)**2-D(I3)**2)/4.0                                RED20065
      AMI2=PI*(C(I3)**4-D(I3)**4)/64.0                                RED20066
      JMAT=J(I3)                                                      RED20067
      WT2=AREA2*P(JMAT)                                               RED20068
      STIF2=H(JMAT)*AMI2                                              RED20069
      ST=STIF1+STIF2                                                  RED20070
      WAIT=WT1+WT2                                                    RED20071
66    IF(L(I3))70,75,70                                               RED20072
70    AREA3=PI*(B(I3)**2)/4.0                                         RED20073
```

```
      WT3=AREA3*P(7)                                              RED20074
      WAIT=WAIT-WT3                                               RED20075
   75 IF(IS(I3))77,78,77                                          RED20076
   77 IF(D(I3))68,69,68                                           RED20077
   69 WT4=(PI*C(I3)**2/4.0)*P(6)                                  RED20078
      GO TO 85                                                    RED20079
   68 WT4=(PI*D(I3)**2/4.0)*P(6)                                  RED20080
   85 WAIT=WAIT+WT4                                               RED20081
   78 D(I3)=WAIT                                                  RED20082
      C(I3)=ST                                                    RED20083
   79 CONTINUE                                                    RED20084
   80 RETURN                                                      RED20085
      END                                                         RED20086
```

```
$IBFTC DEFL     DECK                                                    DEFL0001
      SUBROUTINE DEFLN                                                  DEFL0002
C     DEFLECTION FOR MGE2, MGE5                                         DEFL0003
      DIMENSION DISTL(401),DIA(401),STIFX(401),WTS(401),CONWT(401),     DEFL0004
     1IM(401),JM(401),IBRG(401),IWATR(401),IS(401),YMAT(7),DENMAT(7),   DEFL0005
     2DISTT(401), BMTAB(1620),THETA(802),DEF(401),BNFLU(25,25),DIBRG(25)DEFL0006
     3,IBTAB(25), SFTAB(1620),TITL2(12),NO(400)                         DEFL0007
      COMMON N,NO,DISTL,DIA,STIFX,WTS,CONWT,IM,JM,IBRG,                 DEFL0008
     1 IWATR,IS,YMAT,DENMAT,DISTT,BMTAB,THETA,DEF,BNFLU,DIBRG,IBTAB,    DEFL0009
     2  IBRS,SFTAB,I2,IERROR,       TITL2,IXM                           DEFL0010
      DIMENSION NS(50)                                                  DEFL0011
      COMMON SWAT,NS,IYM                                                DEFL0012
      DO 2 II=1,6                                                       DEFL0013
      SFTAB(II)=0.0                                                     DEFL0014
    2 BMTAB(II)=0.0                                                     DEFL0015
      SFTAB(4)=CONWT(1)                                                 DEFL0016
    5 DO 40 L=1,N                                                       DEFL0017
      I=4*L                                                             DEFL0018
   10 DO 20 J=1,4                                                       DEFL0019
      MA=I+J                                                            DEFL0020
      SFTAB(MA)=SFTAB(MA-1 )+(WTS(L)*DISTT(L))                          DEFL0021
   20 BMTAB(MA)=(SFTAB(MA-1)+SFTAB(MA))/2.*DISTT(L)+BMTAB(MA-1)         DEFL0022
   14 SFTAB(MA)=SFTAB(MA)+CONWT(L+1)                                    DEFL0023
   40 CONTINUE                                                          DEFL0024
      DO 30 M=1,N                                                       DEFL0025
      IK = M+M                                                          DEFL0026
      I = IK+IK                                                         DEFL0027
      THETA(IK) =DISTT(M)/3.0*(BMTAB(I)+BMTAB(I+2)+(4.0*BMTAB(I+1)))/   DEFL0028
     1STIFX(M) +THETA(IK-1)                                             DEFL0029
      THETA(IK+1) = DISTT(M)/3.0*(BMTAB(I+2) +BMTAB(I+4)+(4.0*BMTAB(I+3)DEFL0030
     1))/STIFX(M)+THETA(IK)                                             DEFL0031
   30 DEF(M+1) =2.0/3.0*DISTT(M)*(THETA(IK+1)+THETA(IK-1)+(4.0*THETA(IK)DEFL0032
     1 )) +DEF(M)                                                       DEFL0033
      RETURN                                                            DEFL0034
      END                                                               DEFL0035
```

```
$IBFTC BEAM2   DECK                                                    BEAM0002
      SUBROUTINE BEAM                                                  BEAM0003
C     BEAM SUBROUTINE FOR MGE2 AND MGE5                                BEAM0004
      COMMON N,NO,DISTL,DIA,STIFX,WTS,CONWT,IM,JM,IBRG,                BEAM0005
     1 IWATR,IS,YMAT,DENMAT,DISTT,BMTAB,THETA,DEF,BNFLU,DIBRG,IBTAB,   BEAM0006
     2  IBRS,SFTAB,I2,IERROR,       TITL2,IXM                          BEAM0007
       DIMENSION DISTL(401),DIA(401),STIFX(401),WTS(401),CONWT(401),   BEAM0008
     1IM(401),JM(401),IBRG(401),IWATR(401),IS(401),YMAT(7),DENMAT(7),  BEAM0009
     2DISTT(401), BMTAB(1620),THETA(802),DEF(401),BNFLU(25,25),DIBRG(25)BEAM0010
     3,IBTAB(25), SFTAB(1620),TITL2(12),NO(400)                        BEAM0011
      DIMENSION NS(50)                                                 BEAM0012
      COMMON SWAT,NS,IYM                                               BEAM0013
      I1=IBTAB(1)                                                      BEAM0014
       ISEND = IBTAB(IBRS)                                             BEAM0015
      CONWT(I1)=( BMTAB(I2)-(SFTAB(I2)*(DISTL(N+1)-DIBRG(IBRS))))/     BEAM0016
     1(DIBRG(1)-DIBRG(IBRS))               +CONWT(I1)                  BEAM0017
      CONWT(ISEND)=(BMTAB(I2)-(SFTAB(I2)*(DISTL(N+1)-DIBRG(1))))/      BEAM0018
     1(DIBRG(IBRS)-DIBRG(1))               +CONWT(ISEND)               BEAM0019
      RETURN                                                           BEAM0020
       END                                                             BEAM0021
```

```
$IBFTC INFN    DECK                                                     INFN0001
C      INFLUENCE NUMBERS FOR MGE2, MGE5                                 INFN0003
        SUBROUTINE INFNOS                                               INFN0002
        DIMENSION DISTL(401),DIA(401),STIFX(401),WTS(401),CONWT(401),   INFN0004
     1IM(401),JM(401),IBRG(401),IWATR(401),IS(401),YMAT(7),DENMAT(7),   INFN0005
     2DISTT(401), BMTAB(1620),THETA(802),DEF(401),BNFLU(25,25),DIBRG(25)INFN0006
     3,IBTAB(25), SFTAB(1620),TITL2(12),NO(400)                         INFN0007
      COMMON N,NO,DISTL,DIA,STIFX,WTS,CONWT,IM,JM,IBRG,                 INFN0008
     1 IWATR,IS,YMAT,DENMAT,DISTT,BMTAB,THETA,DEF,BNFLU,DIBRG,IBTAB,    INFN0009
     2  IBRS,SFTAB,I2,IERROR,       TITL2,IXM                           INFN0010
      DIMENSION NS(50)                                                  INFN0011
      COMMON SWAT,NS,IYM                                                INFN0012
      N1=3                                                              INFN0013
      NTWO = N+N                                                        INFN0014
      NFOR = NTWO+NTWO                                                  INFN0015
      DO 99 I1=1,N                                                      INFN0016
      N2=2                                                              INFN0017
      IF (IBRG(I1)) 60,99,60                                            INFN0018
   60 DO 63 I3=1,N                                                      INFN0019
   63 DEF(I3)=0.0                                                       INFN0020
      DO 64 I32=1,NTWO                                                  INFN0021
   64 THETA(I32)=0.0                                                    INFN0022
      DO 65 I34=1,NFOR                                                  INFN0023
   65 BMTAB(I34)=0.0                                                    INFN0024
      DO 95 J1=I1,N                                                     INFN0025
      I4=4*J1                                                           INFN0026
      DO 75 J2=1,4                                                      INFN0027
      K1=I4+J2                                                          INFN0028
   75 BMTAB(K1)=DISTT(J1)+BMTAB(K1-1)                                   INFN0029
      K2=2*J1                                                           INFN0030
      THETA(K2)=DISTT(J1)*(BMTAB(K1-4)+BMTAB(K1-2)+(4.0*BMTAB(K1-3)))/(SINFN0031
     1TIFX(J1)*3.0)   +THETA(K2-1)                                      INFN0032
      THETA(K2+1)=DISTT(J1)*(BMTAB(K1)+BMTAB(K1-2)+(4.0*BMTAB(K1-1)))/(SINFN0033
     1TIFX(J1)*3.0)   +THETA(K2)                                        INFN0034
   95 DEF(J1)=(2.0/3.0)*DISTT(J1)*(THETA(K2+1)+THETA(K2-1)+(4.0*THETA(K2INFN0035
     1)) )  +DEF(J1-1)                                                  INFN0036
```

```
      DO 97 J3=1,N                                                      INFN0037
      IF(IBRG(J3))96,97,96                                              INFN0038
   96 BNFLU(N1,N2)=DEF(J3-1)                                            INFN0039
      N2=N2+1                                                           INFN0040
   97 CONTINUE                                                          INFN0041
      N1=N1+1                                                           INFN0042
   99 CONTINUE                                                          INFN0043
  100 RETURN                                                            INFN0044
      END                                                               INFN0045
```

```
$IBFTC INOU    DECK                                                       1
      SUBROUTINE INOUT                                            INOU0002
C        INOUT FOR MGE2, MGE5                                     INOU0003
       DIMENSION DISTL(401),DIA(401),STIFX(401),WTS(401),CONWT(401),  INOU0004
     1IM(401),JM(401),IBRG(401),IWATR(401),IS(401),YMAT(7),DENMAT(7),  INOU0005
     2DISTT(401), BMTAB(1620),THETA(802),DEF(401),BNFLU(25,25),DIBRG(25)INOU0006
     3,IBTAB(25), SFTAB(1620),TITL2(12),NO(400)                  INOU0007
      COMMON N,NO,DISTL,DIA,STIFX,WTS,CONWT,IM,JM,IBRG,          INOU0008
     1 IWATR,IS,YMAT,DENMAT,DISTT,BMTAB,THETA,DEF,BNFLU,DIBRG,IBTAB,  INOU0009
     2  IBRS,SFTAB,I2,IERROR,       TITL2,IXM                    INOU0010
      DIMENSION NS(50)                                           INOU0011
      COMMON SWAT,NS,IYM                                         INOU0012
      IBRS = 0                                                   INOU0013
      DO 2 I1=1,22                                               INOU0014
    2  IBTAB(I1) = 0.0                                           INOU0015
      DO 70 I1=1,N                                               INOU0016
      IF (IBRG(I1))70,70,65                                      INOU0017
   65 IBRS = IBRS +1                                             INOU0018
      IBTAB(IBRS) = I1                                           INOU0019
      DIBRG(IBRS) = DISTL(I1)                                    INOU0020
   70 CONTINUE                                                   INOU0021
      IBR1=IBRS+1                                                INOU0022
      IBR2=IBRS+2                                                INOU0023
      BNFLU(1,1) =0.0                                            INOU0024
      BNFLU(2,1) =0.0                                            INOU0025
      BNFLU(1,IBR2 ) = 0.0                                       INOU0026
      BNFLU(2,IBR2 ) = 0.0                                       INOU0027
      DO 102 J5=2,IBR1                                           INOU0028
      BNFLU(1,J5)=1.0                                            INOU0029
      BNFLU(2,J5)=DIBRG(J5-1)                                    INOU0030
      BNFLU(J5+1, 1) = DIBRG(J5-1)                               INOU0031
      BNFLU(J5+1, IBR2) = 1.0                                    INOU0032
  102  CONTINUE                                                  INOU0033
      CALL MATINV(BNFLU,IBR2,STOR,0,DETERM,ID)                   INOU0034
       GO TO (231,610), ID                                       INOU0035
  231  DO 600 K7= 1,IBRS                                         INOU0036
```

```
       NK7 = IBRS-K7+1                                                   INOU0037
      BNFLU(25,NK7) = BNFLU(NK7+1,2)                                    INOU0038
  600 BNFLU(24,NK7) = BNFLU(NK7+1,1)                                    INOU0039
      DO 236 K8 = 1,IBRS                                                INOU0040
      DO 236 K7 =1,IBRS                                                 INOU0041
  236 BNFLU(K7,K8) = BNFLU(K7+1,K8+2) *.001                             INOU0042
  550 CONTINUE                                                          INOU0043
  551 RETURN                                                            INOU0044
C     ERROR SET FOR SINGULAR ARRY                                       INOU0045
  610 WRITE(6,611)                                                      INOU0046
  611  FORMAT(29H0 SINGULAR INFLUENCE NUMBERS    ///)                   INOU0047
      IERROR = 2                                                        INOU0048
      GO TO 551                                                         INOU0049
      END                                                               INOU0050
```

```
$IBFTC MAT2     DECK
C     MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LINEAR EQUATIONS    MAT20002
C     INTERNAL DOUBLE PRECISION        PIVOT METHOD                      MAT20003
C     NOVEMBER 1692    S GOOD   DAVID TAYLOR MODEL BASIN    AM MAT2      MAT20004
C                                                                         MAT20005
      SUBROUTINE MATINV(A,N1,B,M1,DETERM,ID)                              MAT20006
C                                                                         MAT20007
C     GENERAL FORM OF DIMENSION STATEMENT                                 MAT20008
C     DIMENSION    A(  ,  ),B(  ,  ),INDEX(  ,3),A1(  ,  ),B1(  ,  )    MAT20009
C                                                                         MAT20010
      DIMENSION    A(25,25),B( 1, 1),INDEX(25,3) ,A1(25,25),B1(1,1)
      EQUIVALENCE (IROW,JROW), (ICOLUM,JCOLUM), (AMAX, T, SWAP)          MAT20012
       EQUIVALENCE (T4,PIVOT1),(T5,PIVOT)                                 MAT20013
C                                                                         MAT20014
C     INITIALIZATION                                                      MAT20015
C                                                                         MAT20016
      N=N1                                                                MAT20017
      M=M1                                                                MAT20018
   10 DETERM=1.0                                                          MAT20019
       D TERM1=0.0                                                        MAT20020
   15 DO 20 J=1,N                                                         MAT20021
      DO 17 I=1,N                                                         MAT20022
   17 A1(J,I) = 0.0                                                       MAT20023
      IF(M) 20,20,19                                                      MAT20024
   19 DO 18 I =1,M                                                        MAT20025
   18 B1(J,I) = 0.0                                                       MAT20026
   20 INDEX(J,3) = 0                                                      MAT20027
   30 DO 550 I=1,N                                                        MAT20028
C                                                                         MAT20029
C     SEARCH FOR PIVOT ELEMENT                                            MAT20030
C                                                                         MAT20031
   40 AMAX=0.0                                                            MAT20032
   45 DO 105 J=1,N                                                        MAT20033
      IF(INDEX(J,3)-1) 60, 105, 60                                        MAT20034
   60 DO 100 K=1,N                                                        MAT20035
      IF(INDEX(K,3)-1) 80, 100, 715                                       MAT20036
```

```
 80 IF(AMAX-ABS(A(J,K)))85,100,100                                    MAT20037
 85 IROW=J                                                            MAT20038
 90 ICOLUM=K                                                          MAT20039
    AMAX=ABS(A(J,K))                                                  MAT20040
100 CONTINUE                                                          MAT20041
105 CONTINUE                                                          MAT20042
    INDEX(ICOLUM,3) = INDEX(ICOLUM,3) +1                              MAT20043
260 INDEX(I,1)=IROW                                                   MAT20044
270 INDEX(I,2)=ICOLUM                                                 MAT20045
C                                                                     MAT20046
C      INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL              MAT20047
C                                                                     MAT20048
130 IF (IROW-ICOLUM) 140, 310, 140                                    MAT20049
140 DETERM=-DETERM                                                    MAT20050
     D TERM1=-D TERM1                                                 MAT20051
150 DO 200 L=1,N                                                      MAT20052
     SWAP=A1(IROW,L)                                                  MAT20000
     A1(IROW,L)=A1(ICOLUM,L   )                                       MAT20053
     A1(ICOLUM,L)=SWAP                                                MAT20054
160 SWAP=A(IROW,L)                                                    MAT20055
170 A(IROW,L)=A(ICOLUM,L)                                             MAT20056
200 A(ICOLUM,L)=SWAP                                                  MAT20057
    IF(M) 310, 310, 210                                               MAT20058
210 DO 250 L=1, M                                                     MAT20059
     SWAP =B1(IROW,L)                                                 MAT20060
    B1(IROW,L)=B1(ICOLUM,L)                                           MAT20061
     B1(ICOLUM,L)=SWAP                                                MAT20062
220 SWAP=B(IROW,L)                                                    MAT20063
230 B(IROW,L)=B(ICOLUM,L)                                             MAT20064
250 B(ICOLUM,L)=SWAP                                                  MAT20065
C                                                                     MAT20066
C      DIVIDE PIVOT ROW BY PIVOT ELEMENT                              MAT20067
C                                                                     MAT20068
310 PIVOT    =A(ICOLUM,ICOLUM)                                        MAT20069
     PIVOT1    =A1(ICOLUM,ICOLUM)                                     MAT20070
320  CALL FMP(DETERM,D TERM1,PIVOT     ,PIVOT1   ,DETERM,D TERM1)     MAT20071
```

```
  330 A(ICOLUM,ICOLUM)=1.0                                                MAT20072
      A1(ICOLUM,ICOLUM)=0.0                                               MAT20073
  340 DO 350 L=1,N                                                        MAT20074
  350  CALL FDY(A(ICOLUM,L),A1(ICOLUM,L),PIVOT    ,PIVOT1   ,             MAT20075
     1            A(ICOLUM,L),A1(ICOLUM,L))                               MAT20076
  355 IF(M) 380, 380, 360                                                 MAT20077
  360 DO 370 L=1,M                                                        MAT20078
  370 CALL FDY(B(ICOLUM,L),B1(ICOLUM,L),PIVOT    ,PIVOT1     ,            MAT20079
     1            B(ICOLUM,L),B1(ICOLUM,L))                               MAT20080
C                                                                         MAT20081
C     REDUCE NON-PIVOT ROWS                                               MAT20082
C                                                                         MAT20083
  380 DO 550 L1=1,N                                                       MAT20084
  390 IF(L1-ICOLUM) 400, 550, 400                                         MAT20085
  400 T=A(L1,ICOLUM)                                                      MAT20086
       T1 = A1(L1,ICOLUM)                                                 MAT20087
  420 A(L1,ICOLUM)=0.0                                                    MAT20088
       A1(L1,ICOLUM) = 0.0                                                MAT20089
  430 DO 450 L=1,N                                                        MAT20090
      CALL FMP (T,T1,A(ICOLUM,L),A1(ICOLUM,L),T4,T5)                      MAT20091
 450  CALL FSB (A(L1,L),A1(L1,L),T4,T5,A(L1,L),A1(L1,L))                  MAT20092
  455 IF(M) 550, 550, 460                                                 MAT20093
  460 DO 500 L=1,M                                                        MAT20094
      CALL FMP (T,T1,B(ICOLUM,L),B1(ICOLUM,L),T4,T5)                      MAT20095
  500 CALL FSB (B(L1,L),B1(L1,L),T4,T5,B(L1,L),B1(L1,L))                  MAT20096
  550 CONTINUE                                                            MAT20097
C                                                                         MAT20098
C     INTERCHANGE COLUMNS                                                 MAT20099
C                                                                         MAT20100
  600 DO 710 I=1,N                                                        MAT20101
  610 L=N+1-I                                                             MAT20102
  620 IF (INDEX(L,1)-INDEX(L,2)) 630, 710, 630                            MAT20103
  630 JROW=INDEX(L,1)                                                     MAT20104
  640 JCOLUM=INDEX(L,2)                                                   MAT20105
  650 DO 705 K=1,N                                                        MAT20106
      SWAP = A1(K,JROW)                                                   MAT20107
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```
         A1(K,JROW)   = A1(K,JCOLUM)                                  MAT20108
         A1(K,JCOLUM) = SWAP                                          MAT20109
  660 SWAP=A(K,JROW)                                                  MAT20110
  670 A(K,JROW)=A(K,JCOLUM)                                           MAT20111
  700 A(K,JCOLUM)=SWAP                                                MAT20112
  705 CONTINUE                                                        MAT20113
  710 CONTINUE                                                        MAT20114
      DO 730 K = 1,N                                                  MAT20115
      IF(INDEX(K,3) -1) 715,720,715                                   MAT20116
  715 ID =2                                                           MAT20117
      GO TO 740                                                       MAT20118
  720 CONTINUE                                                        MAT20119
  730 CONTINUE                                                        MAT20120
      ID =1                                                           MAT20121
  740 RETURN                                                          MAT20122
C     LAST CARD OF PROGRAM                                            MAT20123
      END                                                             MAT20124
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$IBMAP DPAF    DECK                                                    DPAF0001
*      DOUBLE PRECISION  FORTRAN  PACKAGE   7090  BE  SYS3             DPAF0002
       ENTRY   FAD                                                     DPAF0003
       ENTRY   FSB                                                     DPAF0004
       ENTRY   FMP                                                     DPAF0005
       ENTRY   FDY                                                     DPAF0006
       ENTRY   TEST                                                    DPAF0007
 FAD   SXA     END+2,2                                                 DPAF0008
       TXI *+1,4,-2                                                    DPAF0009
       TSX ALL,2                                                       DPAF0010
       CLA COMMON+2            B1                                      DPAF0011
 FADE  FAD COMMON              A1                                      DPAF0012
       STO COMMON                                                      DPAF0013
       CLA COMMON+1            A2                                      DPAF0014
       STQ COMMON+1                                                    DPAF0015
       FAD COMMON+3            B2                                      DPAF0016
       FAD COMMON+1                                                    DPAF0017
       FAD COMMON                                                      DPAF0018
 END   STO*    5,4                                                     DPAF0019
       STQ*    6,4                                                     DPAF0020
       AXT     **,2                                                    DPAF0021
       TRA 7,4                                                         DPAF0022
 FSB   SXA     END+2,2                                                 DPAF0023
       TXI *+1,4,-2                                                    DPAF0024
       TSX ALL,2                                                       DPAF0025
       CLS COMMON+3           CHANGE SIGN B AND ADD                    DPAF0026
       STO COMMON+3                                                    DPAF0027
       CLS COMMON+2                                                    DPAF0028
       TXL FADE,,**                                                    DPAF0029
 ALL   CLA*    1,4            SECURE INPUTS AND OUTPUT                 DPAF0030
       STO COMMON                                                      DPAF0031
       CLA*    2,4                                                     DPAF0032
       STO COMMON+1                                                    DPAF0033
       CLA*    3,4                                                     DPAF0034
       STO COMMON+2                                                    DPAF0035
       CLA*    4,4                                                     DPAF0036
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        STO COMMON+3                                      DPAF0037
        TRA 1,2                                           DPAF0038
FMP     SXA     END+2,2                                   DPAF0039
        TXI *+1,4,-2                                      DPAF0040
        TSX ALL,2                                         DPAF0041
        LDQ COMMON                                        DPAF0042
        FMP COMMON+3        A1 TIMES B2                   DPAF0043
        STO COMMON+3                                      DPAF0044
        LDQ COMMON                                        DPAF0045
        FMP COMMON+2        A1 TIMES B1                   DPAF0046
        STQ COMMON                                        DPAF0047
        LDQ COMMON+1                                      DPAF0048
        STO COMMON+1                                      DPAF0049
        FMP COMMON+2        A2 TIMES B1                   DPAF0050
        FAD COMMON+3                                      DPAF0051
        FAD COMMON                                        DPAF0052
        FAD COMMON+1                                      DPAF0053
        TRA END                                           DPAF0054
FDY     SXA     END+2,2                                   DPAF0055
        TXI *+1,4,-2                                      DPAF0056
        TSX ALL,2                                         DPAF0057
        CLA COMMON          A1 OVER B1                    DPAF0058
        FDP COMMON+2                                      DPAF0059
        STQ COMMON                                        DPAF0060
        FAD COMMON+1        REMAINDER A1 OVER B1 + A2     DPAF0061
        FDP COMMON+2        DIVIDE BY B1                  DPAF0062
        STQ COMMON+1                                      DPAF0063
        CLA COMMON+3                                      DPAF0064
        ANA FDYC            ISOLATE POWER                 DPAF0065
        FSB COMMON+3                                      DPAF0066
        FDP COMMON+2        -B2 OVER B1                   DPAF0067
        FMP COMMON          TIMES A1 OVER B1              DPAF0068
        FAD COMMON+1        ADD LESSER PARTS              DPAF0069
        FAD COMMON          ADD A1 OVER B1                DPAF0070
        DCT                                               DPAF0071
        TRA ERR                                           DPAF0072
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         TRA END                                                        DPAF0073
   FDYC  OCT 377000000000                                               DPAF0074
   TEST  LDQ TESTC                                                      DPAF0075
         TXI *+1,4,-2                                                   DPAF0076
         STQ      END                                                   DPAF0077
         TRA      FSB                                                   DPAF0078
   TESTR LDQ TESTC+1                                                    DPAF0079
         STQ      END                                                   DPAF0080
         TMI      TESTX+2                                               DPAF0081
         FSB*     5,4                                                   DPAF0082
         TMI TESTX+4                                                    DPAF0083
         CLA      ERR-1           PLUS ONE                              DPAF0084
   TESTX LXA  END+2,2                                                   DPAF0085
         TRA 6,4                                                        DPAF0086
         FAD*     5,4                                                   DPAF0087
         TMI      TESTX+6                                               DPAF0088
         ZAC                      ZEERO                                 DPAF0089
         TRA TESTX                                                      DPAF0090
         CLS      ERR-1           MINUS ONE                             DPAF0091
         TRA TESTX                                                      DPAF0092
         DEC 1.                                                         DPAF0093
  ERR    SXA      ERR+4,4                                               DPAF0094
         TSX .MWR,4                      MAP        PRINT BUT PROCEED   DPAF0095
         PZE 1          7/14/64                                         DPAF0096
         PZE FORM,,5                                                    DPAF0097
         AXT      **,4                                                  DPAF0098
         TRA END                                                        DPAF0099
   FORM  BCI      5, DBL PREC DIV CKECK                                 DPAF0100
   TESTC TRA TESTR                                                      DPAF0101
         STO*   5,4                                                     DPAF0102
  COMMON BSS 4                                                          DPAF0103
         END                                                            DPAF0104
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$IBFTC GRAPH2  DECK                                                     GRAP0001
      SUBROUTINE GRAPH                                                  GRAP0002
C     DIMENSION AS IN MGE2                                              GRAP0003
      DIMENSION DISTL(401),DIA(401),STIFX(401),WTS(401),CONWT(401),     GRAP0004
     1IM(401),JM(401),IBRG(401),IWATR(401),IS(401),YMAT(7),DENMAT(7),   GRAP0005
     2DISTT(401), BMTAB(1620),THETA(802),DEF(401),BNFLU(25,25),DIBRG(25)GRAP0006
     3,IBTAB(25), SFTAB(1620),TITL2(12),NO(400)                         GRAP0007
C     COMMON  AS IN  MGE2                                               GRAP0008
      COMMON N,NO,DISTL,DIA,STIFX,WTS,CONWT,IM,JM,IBRG,                 GRAP0009
     2  IBRS,SFTAB,I2,IERROR,       TITL2,IXM                           GRAP0011
      DIMENSION IPLT(23) , GTITLE (21)                                  GRAP0012
      DATA GTITLE(1)/6H(74H  /                                          GRAP0013
      CALL LGCHAR (8,4HMGE2)                                            GRAP0014
      K=N+1                                                             GRAP0015
      DO  30 I=1,K                                                      GRAP0016
   30 BMTAB(I)= BMTAB(4*I)/1000.                                        GRAP0017
      PLOT1=450.                                                        GRAP0018
      I5=1                                                              GRAP0019
      IGP=9                                                             GRAP0020
      IGS = 1                                                           GRAP0021
      IFF=1                                                             GRAP0022
      DO1IF=1,23                                                        GRAP0023
    1 IPLT(IF)=0                                                        GRAP0024
C     COLLECT BEARING POINTS FOR PLOT                                   GRAP0025
      DO22I3=1, IBRS                                                    GRAP0026
      I4 = IBTAB(I3)                                                    GRAP0027
      BNFLU (I3,1)= DISTL(I4)                                           GRAP0028
      BNFLU (I3,2)= DEF  (I4)                                           GRAP0029
   22 BNFLU (I3,3)=BMTAB (I4)                                           GRAP0030
      IF(K-99 ) 5, 5 , 4                                                GRAP0031
    5 PLOT1 =AINT  ((DISTL(K)+99.)/100.)*100.                           GRAP0032
      IPLT(2)=K                                                         GRAP0033
      IFF=1                                                             GRAP0034
      IGP = (PLOT1+99.)*.01                                             GRAP0035
      IGS = 2                                                           GRAP0036
      IF(IGP-35) 9,9,19                                                 GRAP0037
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   19 IGP = (IGP+1)/2                                                     GRAP0038
       GO TO 9                                                            GRAP0039
    4  DO 2 IF=1,K                                                        GRAP0040
       IF(DISTL(IF)-PLOT1 )  2 ,  2  ,  3                                 GRAP0041
    3  IPLT(IFF+1)= IF-1                                                  GRAP0042
       IFF= IFF+1                                                         GRAP0043
       PLOT1=PLOT1+450.                                                   GRAP0044
    2  CONTINUE                                                           GRAP0045
      IPLT(IFF+1)=K                                                       GRAP0046
C      HAVE NO OF FRAMES  SET  UP                                         GRAP0047
      PLOT1 = 450.0                                                       GRAP0048
C      COMPUTE SCALES FOR DEFL. AND BEND. MOMENT                          GRAP0049
    9  GDEF=0.                                                            GRAP0050
       DO  6  I=1,K                                                       GRAP0051
       IF(ABS (DEF(I))-GDEF) 6, 6, 8                                      GRAP0052
    8  GDEF = ABS (DEF(I))                                                GRAP0053
    6 CONTINUE                                                            GRAP0054
       GBML = 0.                                                          GRAP0055
       GBMH = 0.                                                          GRAP0056
       DO. 12  I=1,K                                                      GRAP0057
       IF (BMTAB(I)) 10,12, 11                                            GRAP0058
   10  IF (BMTAB(I)-GBML ) 13,12,12                                       GRAP0059
   13  GBML=BMTAB(I)                                                      GRAP0060
       GO TO 12                                                           GRAP0061
   11  IF (BMTAB(I) -GBMH) 12, 12,14                                      GRAP0062
   14  GBMH = BMTAB(I)                                                    GRAP0063
   12  CONTINUE                                                           GRAP0064
       GBML=100. *AINT ((GBML -99.)/100.)                                 GRAP0065
       GBMH=100. *AINT ((GBMH +99.)/100.)                                 GRAP0066
      IGBMD=(GBMH-GBML +99.)*.01                                          GRAP0067
      IF(IGBMD-35)24,24,25                                                GRAP0068
   25 IGBMD = (IGBMD+1)/2                                                 GRAP0069
   24  IF(IGBMD-10) 15,15, 16                                             GRAP0070
   15  IGBMD = IGBMD +IGBMD                                               GRAP0071
   16  GDEF=AINT ((GDEF +.0099)*100.) *.01                                GRAP0072
      IGDEF = (GDEF+GDEF+.009)*100.                                       GRAP0073
```

```
      IF(IGDEF -10)  17,17,18                                            GRAP0074
   17 IGDEF =ICDEF +IGDEF                                                GRAP0075
   18 IF(IGDEF-35) 26,26,23                                              GRAP0076
   23 IGDEF =(!GDEF+1)/2                                                 GRAP0077
  26   CONTINUE                                                          GRAP0078
      DO  7  IG=1,20                                                     GRAP0079
    7 GTITLE(IG+1) = TITL2(IG)                                           GRAP0080
      PLOTB=PLOT1                                                        GRAP0081
      PLOTA= 0.                                                          GRAP0082
      DO 20 IC=1,IFF                                                     GRAP0083
      IST  =IPLT(IC  )                                                   GRAP0084
      ISH  =IPLT(IC+1)-IST                                               GRAP0085
     CALL FNPLOT( GTITLE( 1),32H(28H  SECTION DISTANCE IN INCHES,        GRAP0086
    132H(28H  BENCING MOMENT IN KIP FEET,PLOTA,PLOTB, GBML,GBMH,IGP,     GRAP0087
    2 IGS, IGBMD,2 ,  6H(F7.1), 6H(F7.0))                                GRAP0088
      CALL  CURVE  (DISTL(IST), BMTAB(IST)  , ISH, 6H       )            GRAP0089
     I4=0                                                                GRAP0090
      DO41 I3=I5,!BRS                                                    GRAP0091
      IF(IBTAB(I3)-IST) 40,40,50                                         GRAP0092
   40 I4=I4+1                                                            GRAP0093
   41 CONTINUE                                                           GRAP0094
      I5=IBRS+1                                                          GRAP0095
      GO TO 51                                                           GRAP0096
   50 I5=I3                                                              GRAP0097
   51 IF(I4) 52,52,53                                                    GRAP0098
C     GET BEARING VALUES ON DEFL PLOT                                    GRAP0099
   53 CALL  CURVE  (BNFLU(   1,1),BNFLU(   1,3),I4 ,6H     O)            GRAP0100
   52 PLOTA=PLOTB                                                        GRAP0101
   20 PLOTB=PLOTB+450.                                                   GRAP0102
      PLOTB=PLOT1                                                        GRAP0103
      I5 = 1                                                             GRAP0104
      PLOTA=0.                                                           GRAP0105
      DO 21 IC =1,IFF                                                    GRAP0106
      IST  =IPLT(IC  )                                                   GRAP0107
      ISH  =IPLT(IC+1)-IST                                               GRAP0108
      CALL  FNPLOT( GTITLE( 1),32H(28H  SECTION DISTANCE IN INCHES,      GRAP0109
```

```
     126H(22H  DEFLECTION IN INCHES , PLOTA,PLOTB,-GDEF,GDEF,IGP,IGS,    GRAP0110
     2         IGDEF,2, 6H(F7.1),6H(F6.3))                                 GRAP0111
      CALL  CURVE  (DISTL(IST),  DEF (IST) , ISH , 6H       )              GRAP0112
      I4=0                                                                 GRAP0113
      DO 43 I3=I5,IBRS                                                     GRAP0114
      IF(IBTAB(I3)-IST)44,44,45                                            GRAP0115
   44 I4=I4+1                                                              GRAP0116
   43 CONTINUE                                                             GRAP0117
      I5=IBRS+1                                                            GRAP0118
      GO TO 46                                                             GRAP0119
   45 I5=I3                                                                GRAP0120
   46 IF (I4) 54,54 ,55                                                    GRAP0121
 55   CALL  CURVE (BNFLU(    1,1), BNFLU(    1,2),  I4   ,6H     O)        GRAP0122
 54   PLOTA=PLOTB                                                          GRAP0123
 21   PLOTB=PLOTB+450.                                                     GRAP0124
      CALL LGCHAR (8, 4H2END)                                              GRAP0125
       RETURN                                                              GRAP0126
       END                                                                 GRAP0127
```

```
C       LARC VERSION                                                      MAT2L001
C       MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LINEAR EQUATIONS   MAT2L002
C       INTERNAL DOUBLE PRECISION         PIVOT METHOD                    MAT2L003
C       NOVEMBER 1692    S GOOD  DAVID TAYLOR MODEL BASIN    AM MAT2      MAT2L004
C                                                                         MAT2L005
        SUBROUTINE MATINV(A1,N1,B1,M1,DTERM1,ID)                          MAT2L006
C                                                                         MAT2L007
C       GENERAL FORM OF DIMENSION STATEMENT                               MAT2L008
C       DIMENSION    A(  ,  ),B(  ,  ),INDEX(  ,3),A1(  ,  ),B1(  ,  )    MAT2L009
C                                                                         MAT2L010
        EQUIVALENCE (IROW,JROW), (ICOLUM,JCOLUM), (AMAX, T, SWAP)         MAT2L011
        DIMENSIONA(70,70),B(70, 1),INDEX(70,3),A1(70,70),B1(70, 1)        MAT2L012
        DOUBLE PRECISION A,B,DETERM,PIVOT,SWAP,T                          MAT2L013
C                                                                         MAT2L014
C       INITIALIZATION                                                    MAT2L015
C                                                                         MAT2L016
        N=N1                                                              MAT2L017
        M=M1                                                              MAT2L018
     10 DETERM=0.0                                                        MAT2L019
     15 DO 20 J=1,N                                                       MAT2L020
        DO 17 I=1,N                                                       MAT2L021
   17   A(I,J) = A1(I,J)                                                  MAT2L022
        IF(M) 20,20,19                                                    MAT2L023
     19 DO 18 I =1,M                                                      MAT2L024
   18   B(J,I) = B1(J,I)                                                  MAT2L025
     20 INDEX(J,3) = 0                                                    MAT2L026
     30 DO 550 I=1,N                                                      MAT2L027
C                                                                         MAT2L028
C       SEARCH FOR PIVOT ELEMENT                                          MAT2L029
C                                                                         MAT2L030
     40 AMAX=0.0                                                          MAT2L031
     45 DO 105 J=1,N                                                      MAT2L032
        IF(INDEX(J,3)-1) 60, 105, 60                                      MAT2L033
     60 DO 100 K=1,N                                                      MAT2L034
        IF(INDEX(K,3)-1) 80, 100, 715                                     MAT2L035
     80 IF (      AMAX -ABSF(A(J,K))) 85, 100, 100                        MAT2L036
```

```
   85 IROW=J                                                     MAT2L037
   90 ICOLUM=K                                                   MAT2L038
      AMAX = ABSF(A(J,K))                                        MAT2L039
  100 CONTINUE                                                   MAT2L040
  105 CONTINUE                                                   MAT2L041
      INDEX(ICOLUM,3) = INDEX(ICOLUM,3) +1                       MAT2L042
  260 INDEX(I,1)=IROW                                            MAT2L043
  270 INDEX(I,2)=ICOLUM                                          MAT2L044
C                                                                MAT2L045
C     INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL          MAT2L046
C                                                                MAT2L047
  130 IF (IROW-ICOLUM) 140, 310, 140                             MAT2L048
  140 DETERM=-DETERM                                             MAT2L049
  150 DO 200 L=1,N                                               MAT2L050
  160 SWAP=A(IROW,L)                                             MAT2L051
  170 A(IROW,L)=A(ICOLUM,L)                                      MAT2L052
  200 A(ICOLUM,L)=SWAP                                           MAT2L053
      IF(M) 310, 310, 210                                        MAT2L054
  210 DO 250 L=1, M                                              MAT2L055
  220 SWAP=B(IROW,L)                                             MAT2L056
  230 B(IROW,L)=B(ICOLUM,L)                                      MAT2L057
  250 B(ICOLUM,L)=SWAP                                           MAT2L058
C                                                                MAT2L059
C     DIVIDE PIVOT ROW BY PIVOT ELEMENT                          MAT2L060
C                                                                MAT2L061
  310 PIVOT   =A(ICOLUM,ICOLUM)                                  MAT2L062
      DETERM=DETERM*PIVOT                                        MAT2L063
  330 A(ICOLUM,ICOLUM)=1.0                                       MAT2L064
  340 DO 350 L=1,N                                               MAT2L065
  350 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT                              MAT2L066
  355 IF(M) 380, 380, 360                                        MAT2L067
  360 DO 370 L=1,M                                               MAT2L068
  370 B(ICOLUM,L)=B(ICOLUM,L)/PIVOT                              MAT2L069
C                                                                MAT2L070
C     REDUCE NON-PIVOT ROWS                                      MAT2L071
C                                                                MAT2L072
```

```
  380 DO 550 L1=1,N                                         MAT2L073
  390 IF(L1-ICOLUM) 400, 550, 400                           MAT2L074
  400 T=A(L1,ICOLUM)                                        MAT2L075
  420 A(L1,ICOLUM)=0.0                                      MAT2L076
  430 DO 450 L=1,N                                          MAT2L077
  450 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T                         MAT2L078
  455 IF(M) 550, 550, 460                                   MAT2L079
  460 DO 500 L=1,M                                          MAT2L080
  500 B(L1,L)=B(L1,L)-B(ICOLUM,L)*T                         MAT2L081
  550 CONTINUE                                              MAT2L082
C                                                           MAT2L083
C       INTERCHANGE COLUMNS                                 MAT2L084
C                                                           MAT2L085
  600 DO 710 I=1,N                                          MAT2L086
  610 L=N+1-I                                               MAT2L087
  620 IF (INDEX(L,1)-INDEX(L,2)) 630, 710, 630              MAT2L088
  630 JROW=INDEX(L,1)                                       MAT2L089
  640 JCOLUM=INDEX(L,2)                                     MAT2L090
  650 DO 705 K=1,N                                          MAT2L091
  660 SWAP=A(K,JROW)                                        MAT2L092
  670 A(K,JROW)=A(K,JCOLUM)                                 MAT2L093
  700 A(K,JCOLUM)=SWAP                                      MAT2L094
  705 CONTINUE                                              MAT2L095
  710 CONTINUE                                              MAT2L096
      DO 730 K = 1,N                                        MAT2L097
      IF(INDEX(K,3) -1) 715,720,715                         MAT2L098
  715 ID =2                                                 MAT2L099
      GO TO 810                                             MAT2L100
  720 CONTINUE                                              MAT2L101
  730 CONTINUE                                              MAT2L102
      ID =1                                                 MAT2L103
 740   DO 800 J=1,N                                         MAT2L104
       DO 801 I =1,N                                        MAT2L105
  801 A1(I,J) = A(I,J)                                      MAT2L106
      IF(M) 800,800,802                                     MAT2L107
 802   DO 803 I =1,M                                        MAT2L108
```

```
  803  B1(J,I) = B(J,I)                                              MAT2L109
  800  CONTINUE                                                      MAT2L110
       DTERM1 = DETERM                                               MAT2L111
 810    RETURN                                                       MAT2L112
 C     LAST CARD OF PROGRAM                                          MAT2L113
        END
```

MGE2 - SAMPLE INPUT FORM

```
COLUMN          1          2          4          5          6666667  7
1 3 5           6          8          0          2          4567890  3

 SAMPLE CASE     12 BEARING SHAFT     4/1/64                1       TMGE
 01 0.0         8.0                                         3       TMGE
 02 2.0         8.0                                         3       TMGE
 03 4.0         18.0                                        3       TMGE
 04 12.5        18.0                                        1  1    TMGE
 05 24.0        36.0                                        1       TMGE
 06 40.5        36.0                             -23100.0   1       TMGE
 07 57.25       18.0                                        1       TMGE
 08 68.5        18.0                                        3  1    TMGE
 09 93.5        33.0                                        3       TMGE
 10 98.5        18.0                                        3       TMGE
 11 109.5       17.5                                        3       TMGE
 12 122.75      31.0                                        3       TMGE
 13 130.25      17.0                                        3       TMGE
 14 306.5       17.0                                        1  1    TMGE
 15 540.5       17.0                                        3  1    TMGE
 15 590.75      31.0                                        3       TMGE
 17 598.25      17.0                                        3       TMGE
 18 774.5       17.0                                        1  1    TMGE
 19 1008.5      17.0                                        3  1    TMGE
 20 1058.75     31.0                                        3       TMGE
 21 1066.25     17.0                                        3       TMGE
 22 1242.5      17.0                                        1  1    TMGE
 23 1476.5      17.0                                        3  1    TMGE
 24 1526.75     31.0                                        3       TMGE
 25 1534.25     17.0                                        3       TMGE
 26 1698.50     17.0                                        1  1    TMGE
 27 1914.5      17.0                                        3  1    TMGE
```

```
 28 1968.5      34.0                                                3        TMGE
 29 2028.5      19.5625                                             3    1   TMGE
 30 2082.5      21.8125      19.5625                                2  3 1   TMGE
 31 2121.5      21.8125      19.5625                                2  111   TMGE
 32 2160.5      21.375       19.5625                                2  101   TMGE
 33 2371.0      21.8125      19.5625                                2  101   TMGE
 34 2443.0      21.8125      19.5625                                2  311   TMGE
 35 2515.0      19.5625                                             3    1   TMGE
 36 2543.5      19.5625                            -24343.0         3    1   TMGE
 37 2559.5      16.0                                                3    1   TMGE
938 2571.5                                                                   TMGE
 3 3 -0.28355    30000000.                                                   TMGE
07                                                                           TMGE
```

Note: Material 3 as used is identical to Material 1 to illustrate the insertion of new material cards.

*** SHAFTING SYSTEM PROGRAM MGE2 ***

SAMPLE CASE 12 BEARING SHAFT 1/1/63 1

INPUT DATA

STATION NO.	SECTION DISTANCE (INCH)	FIRST DIAMETER (INCH)	SECOND DIAMETER (INCH)	THIRD DIAMETER (INCH)	CONCENTRATED WEIGHT (LB.)	MATERIALS A	MATERIALS B	BEARING POSITION	IN WATER	WITH SAND
1	0.	8.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
2	2.0000	8.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
3	4.0000	18.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
4	12.5000	18.0000	-0.	-0.	-0.	1	-0	1	-0	-0
5	24.0000	36.0000	-0.	-0.	-0.	1	-0	-0	-0	-0
6	40.5000	36.0000	-0.	-0.	-23100.00	1	-0	-0	-0	-0
7	57.2500	18.0000	-0.	-0.	-0.	1	-0	-0	-0	-0
8	68.5000	18.0000	-0.	-0.	-0.	3	-0	1	-0	-0
9	93.5000	33.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
10	98.5000	18.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
11	109.5000	17.5000	-0.	-0.	-0.	3	-0	-0	-0	-0
12	122.7500	31.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
13	130.2500	17.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
14	306.5000	17.0000	-0.	-0.	-0.	1	-0	1	-0	-0
15	540.5000	17.0000	-0.	-0.	-0.	3	-0	1	-0	-0
16	590.7500	31.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
17	598.2500	17.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
18	774.5000	17.0000	-0.	-0.	-0.	1	-0	1	-0	-0
19	1008.5000	17.0000	-0.	-0.	-0.	3	-0	1	-0	-0
20	1058.7500	31.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
21	1066.2500	17.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
22	1242.5000	17.0000	-0.	-0.	-0.	1	-0	1	-0	-0
23	1476.5000	17.0000	-0.	-0.	-0.	3	-0	1	-0	-0
24	1526.7500	31.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
25	1534.2500	17.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
26	1698.5000	17.0000	-0.	-0.	-0.	1	-0	1	-0	-0
27	1914.5000	17.0000	-0.	-0.	-0.	3	-0	1	-0	-0
28	1968.5000	34.0000	-0.	-0.	-0.	3	-0	-0	-0	-0
29	2026.5000	19.5625	-0.	-0.	-0.	3	-0	-0	1	-0
30	2082.5000	21.8125	19.5625	-0.	-0.	2	3	-0	1	-0
31	2121.5000	21.8125	19.5625	-0.	-0.	2	1	1	1	-0
32	2160.5000	21.3750	19.5625	-0.	-0.	2	1	0	1	-0
33	2371.0000	21.8125	19.5625	-0.	-0.	2	1	0	1	-0
34	2443.0000	21.8125	19.5625	-0.	-0.	2	3	1	1	-0
35	2515.0000	19.5625	-0.	-0.	-0.	3	-0	-0	1	-0
36	2543.5000	19.5625	-0.	-0.	-24343.00	3	-0	-0	1	-0
37	2559.5000	16.0000	-0.	-0.	-0.	3	-0	-0	1	-0
38	2571.5000	-0.	-0.	-0.	-0.	0	0	-0	0	-0

SAMPLE CASE   12 BEARING SHAFT   1/1/63   1

UNDRFLOW AT 13633 IN MQ

UNDRFLOW AT 13624 IN MQ

UNDRFLOW AT 13633 IN MQ

UNDRFLOW AT 13634 IN MQ

UNDRFLOW AT 13635 IN MQ

DEFLECTION AND SLOPE INFLUENCE NUMBERS ON STATION 1 (FOR ONE INCH OF RISE OF BEARING)

BRG.NO.	DEFLECTION	SLOPE
1	1.2301325	-0.01841060
2	-0.2321747	0.01857397
3	0.0025792	-0.00020633
4	-0.0006828	0.00005462
5	0.0001842	-0.00001474
6	-0.0000489	0.00000390
7	0.0000132	-0.00000105
8	-0.0000036	0.00000028
9	0.0000010	-0.00000008
10	-0.0000003	0.00000002
11	0.0000001	-0.0000000C
12	-0.0000000	0.00000000

BEST AVAILABLE COPY

SAMPLE CASE 12 BEARING SHAFT 1/1/83 1

BEARING REACTION INFLUENCE NUMBERS (LB. PER 0.001 INCH RISE OF BEARING)

BRG. NO.	1	2	3	4	5	6	7	8	9	10	11
1	622.0	-805.6	231.9	-61.4	16.6	-4.4	1.2	-0.3	0.1	-0.0	0.0
2	-805.6	1058.3	-334.5	104.0	-28.1	7.4	-2.0	0.5	-0.2	0.0	-0.0
3	231.9	-334.5	130.7	-114.9	46.5	-12.3	3.3	-0.9	0.3	-0.1	0.0
4	-61.4	104.0	-114.9	142.7	-104.7	43.5	-11.8	3.2	-0.9	0.3	-0.1
5	16.6	-28.1	46.5	-104.7	139.5	-104.4	43.8	-11.9	3.5	-1.0	0.2
6	-4.4	7.4	-12.3	43.5	-104.4	140.1	-104.3	44.4	-12.9	3.7	-0.9
7	1.2	-2.0	3.3	-11.8	43.8	-104.3	140.5	-108.3	48.3	-13.8	3.4
8	-0.3	0.5	-0.9	3.2	-11.9	44.4	-108.3	152.7	-121.8	54.7	-13.6
9	0.1	-0.2	0.3	-0.9	3.5	-12.9	48.3	-121.8	176.7	-141.8	53.6
10	-0.0	0.0	-0.1	0.3	-1.0	3.7	-13.8	54.7	-141.8	210.5	-143.1
11	0.0	-0.0	0.0	-0.1	0.2	-0.9	3.4	-13.6	53.6	-143.1	142.4
12	-0.0	0.0	-0.0	0.0	-0.0	0.1	-0.3	1.2	-4.8	30.6	-42.0

STRAIGHT LINE BEARING REACTIONS (LBS.)

1	2	3	4	5	6	7	8	9	10	11
11222.6	33679.8	15265.7	15996.5	15239.3	15997.3	15278.8	15845.6	13438.6	23299.6	15898.3

BRG. NO.	12	13	14	15	16	17	18	19	20	21	22
1	-0.0										
2	0.0										
3	-0.0										
4	0.0										
5	-0.0										
6	0.1										
7	-0.3										
8	1.2										
9	-4.8										
10	30.6										
11	-42.0										
12	15.2										

STRAIGHT LINE BEARING REACTIONS (LBS.)

89460.6

SAMPLE CASE 12 BEARING SHAFT 1/1/63

SHAFTING SECTION INTEGRALS

STATION NO.	SHEAR FORCE (KIP.)	MOMENT (KIP.INCH)	SLOPE (RADIANS)	DEFLECTION (INCH)	BEARING REACTION (LBS.)
1	-0.	0.	-0.0000030	0.0000383	0.
2	-0.02851	-0.029	-0.0000030	0.0000322	0.
3	-0.05701	-0.114	-0.0000031	0.0000262	0.
4	10.55231	-3.205	-0.0000031	-0.0000000	11222.6
5	9.72253	113.375	0.0000010	-0.0000203	0.
6	-18.13968	234.509	0.0000022	0.0000055	0.
7	-22.97404	-109.819	0.0000027	0.0000501	0.
8	9.89397	-372.843	-0.0000148	-0.0000000	33679.8
9	8.09011	-148.042	-0.0000563	-0.0009647	0.
10	6.87751	-110.623	-0.0000567	-0.0012472	0.
11	6.08381	-39.335	-0.0000620	-0.0019045	0.
12	5.18013	35.288	-0.0000621	-0.0027341	0.
13	3.57502	68.120	-0.0000618	-0.0031986	0.
14	7.49728	-301.426	0.0000098	-0.0000000	15265.7
15	8.43347	-309.116	-0.0000122	-0.0000003	15906.5
16	5.19937	33.409	-0.0000630	-0.0024780	0.
17	3.59426	66.385	-0.0000628	-0.0029498	0.
18	7.49003	-299.772	0.0000088	-0.0000011	15839.3
19	8.42703	-309.158	-0.0000118	-0.0000028	15997.3
20	5.19293	33.043	-0.0000626	-0.0024573	0.
21	3.58783	65.971	-0.0000623	-0.0029261	0.
22	7.52315	-301.319	0.0000078	-0.0000058	15278.8
23	8.30847	-302.955	-0.0000083	-0.0000198	15848.6
24	5.07437	33.288	-0.0000579	-0.0022493	0.
25	3.46926	65.327	-0.0000576	-0.0026825	0.
26	6.33671	-233.004	0.0000237	-0.0000171	13438.6
27	15.73454	-365.669	-0.0000626	-0.0000260	23299.6
28	12.25909	390.159	-0.0000503	-0.0045678	0.
29	-3.18736	662.311	-0.0000319	-0.0070772	0.
30	-7.18818	382.171	0.0001033	-0.0048337	0.
31	5.03098	30.088	0.0001343	-0.0000358	15898.3
32	1.35180	154.552	0.0001491	0.0054330	0.
33	-17.64124	-1559.911	-0.0001483	0.0297298	0.
34	35.02704	-3074.604	-0.0007453	-0.0000569	59460.6
35	28.23470	-797.181	-0.0012424	-0.0752001	0.
36	1.78016	-22.582	-0.0012959	-0.1116143	0.
37	0.59473	-3.583	-0.0012968	-0.1323576	0.
38	-0.00001	-0.015	-0.0012969	-0.1479202	0.

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SAMPLE CASE   12 BEARING SHAFT   1/1/63   1

SHAFTING WEIGHT AND STIFFNESS FACTORS

STATION NO.	SECTION DISTANCE(INCH)	WEIGHT (LB/IN.)	STIFFNESS(1/EI) (X0.0000000000001)	CONCENTRATED WEIGHT OR REACTION (LB.)	BEARING POSITION
1	0.	-14.2528	165.786400	-0.	-0
2	2.0000	-14.2528	165.786400	-0.	-0
3	4.0000	-72.1547	6.468727	-0.	-0
4	12.5000	-72.1547	6.468727	11282.64	1
5	24.0000	-288.6187	0.404295	-0.	-0
6	40.5000	-288.6187	0.404295	-23100.00	-0
7	57.2500	-72.1547	6.468727	-0.	-0
8	68.5000	-72.1547	6.468727	33679.78	1
9	93.5000	-242.5199	0.572602	-0.	-0
10	98.5000	-72.1547	6.468727	-0.	-0
11	109.5000	-66.2016	7.240302	-0.	-0
12	122.7500	-214.0144	0.735296	-0.	-0
13	130.2500	-64.3602	8.130423	-0.	-0
14	306.5000	-64.3602	8.130423	15265.74	1
15	540.5000	-64.3602	8.130423	15996.47	1
16	590.7500	-214.0144	0.735296	-0.	-0
17	598.2500	-64.3602	8.130423	-0.	-0
18	774.5000	-64.3602	8.130423	15239.26	1
19	1008.5000	-64.3602	8.130423	15997.29	1
20	1058.7500	-214.0144	0.735296	-0.	-0
21	1066.2500	-64.3602	8.130423	-0.	-0
22	1242.5000	-64.3602	8.130423	15276.81	1
23	1476.5000	-64.3602	8.130423	15845.60	1
24	1526.7500	-214.0144	0.735296	-0.	-0
25	1534.2500	-64.3602	8.130423	-0.	-0
26	1698.5000	-64.3602	8.130423	13438.61	1
27	1914.5000	-64.3602	8.130423	23299.63	1
28	1968.5000	-257.4408	0.508151	-0.	-0
29	2028.5000	-74.0893	4.636726	-0.	-0
30	2082.5000	-94.3380	3.642795	-0.	-0
31	2121.5000	-94.3380	3.642795	15898.34	1
32	2160.5000	-90.2282	3.823523	-0.	0
33	2371.0000	-94.3380	3.642795	-0.	0
34	2443.0000	-94.3380	3.642795	59460.61	1
35	2515.0000	-74.0893	4.636726	-0.	-0
36	2543.5000	-74.0893	4.636726	-24343.00	-0
37	2559.5000	-49.5618	10.361650	0.	-0
38	2571.5000	-0.	0.	-0.	-0

TOTAL SHAFT WEIGHT (INCLUDING CONCENTRATED LOADS) = -280622.06 LB.

DISTANCE OF CENTER OF GRAVITY FROM STATION NO. 1 = 1326.7418 INCH

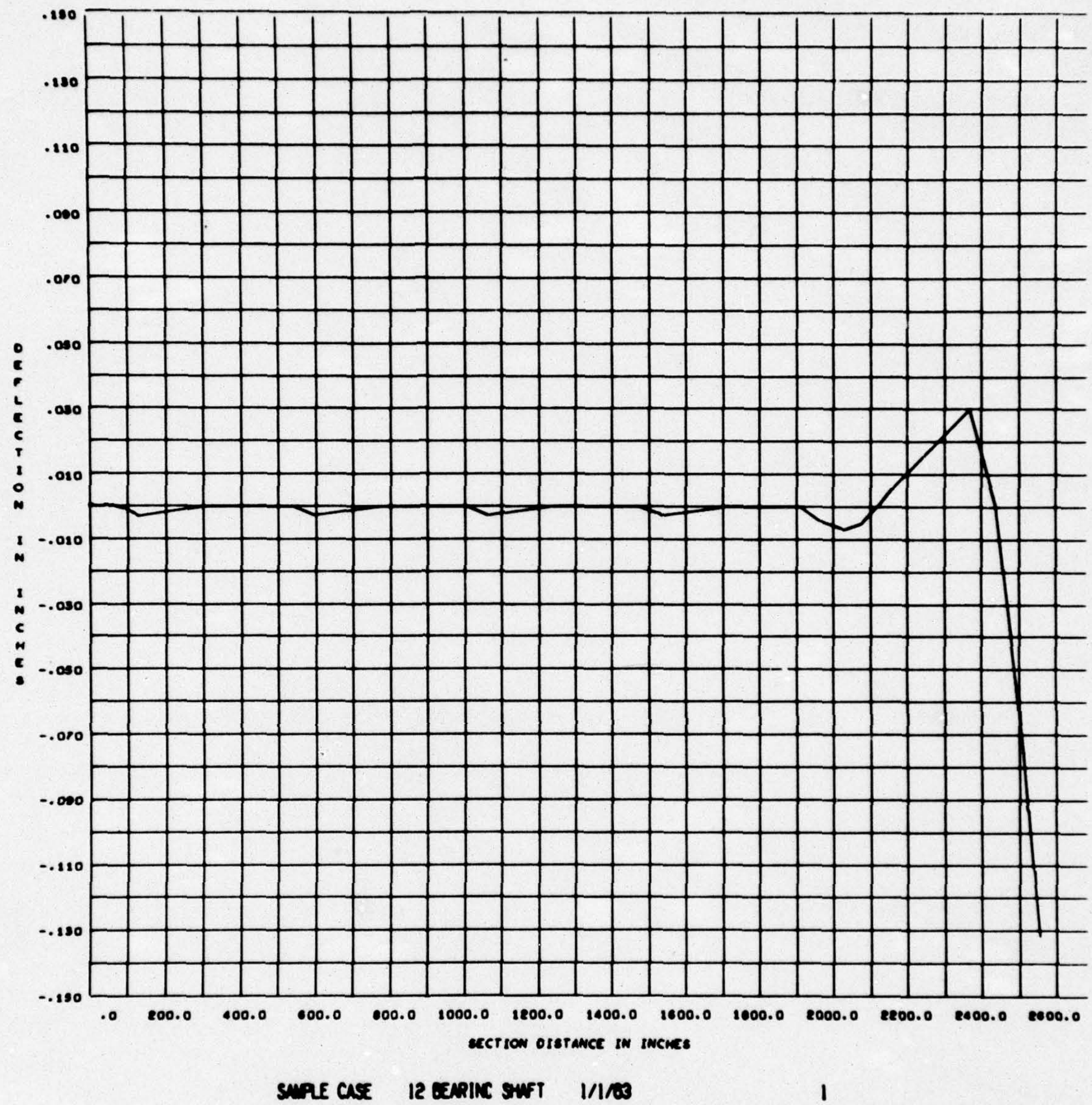


Figure A. 1 - Sample Graphic Output

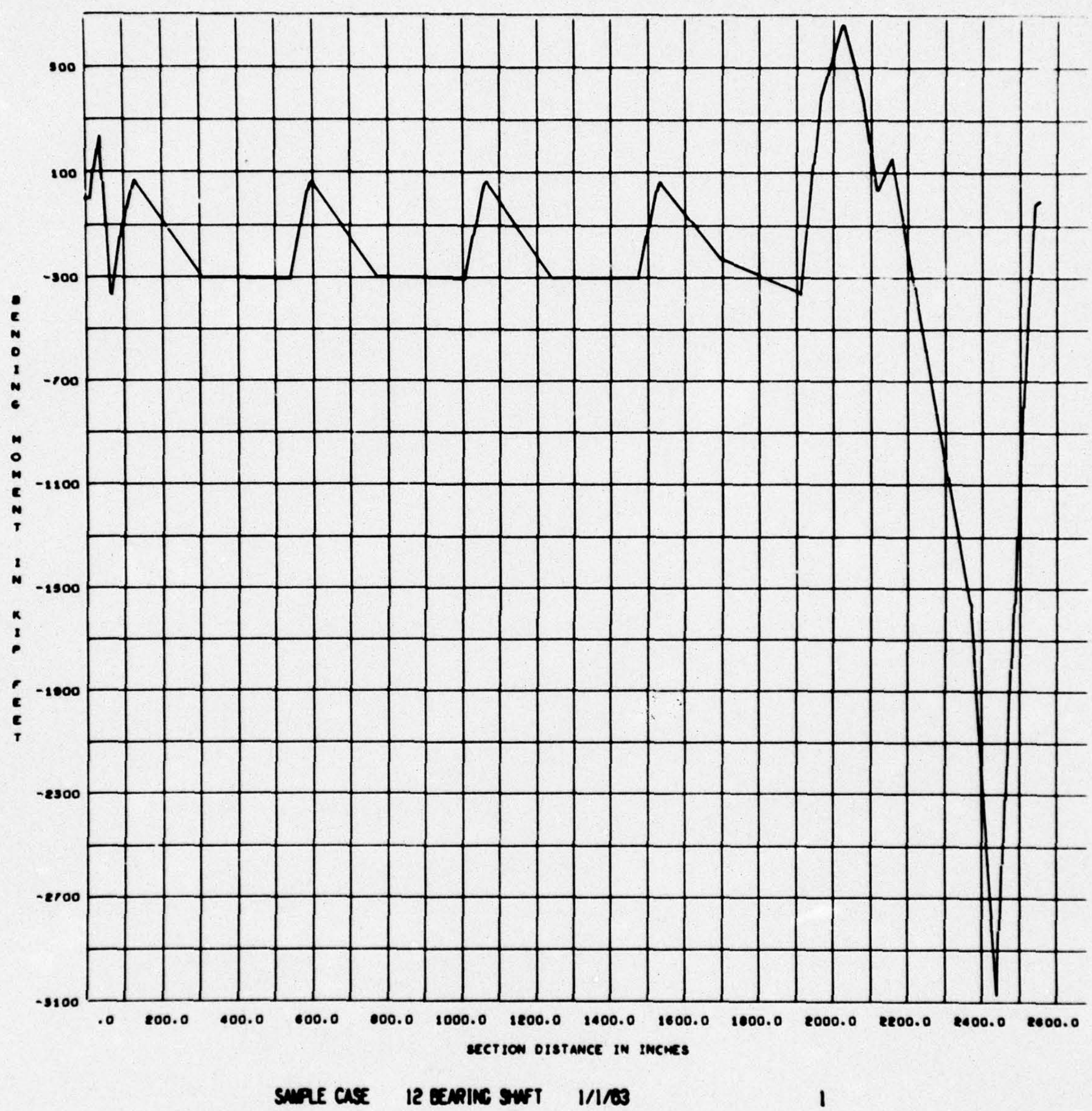
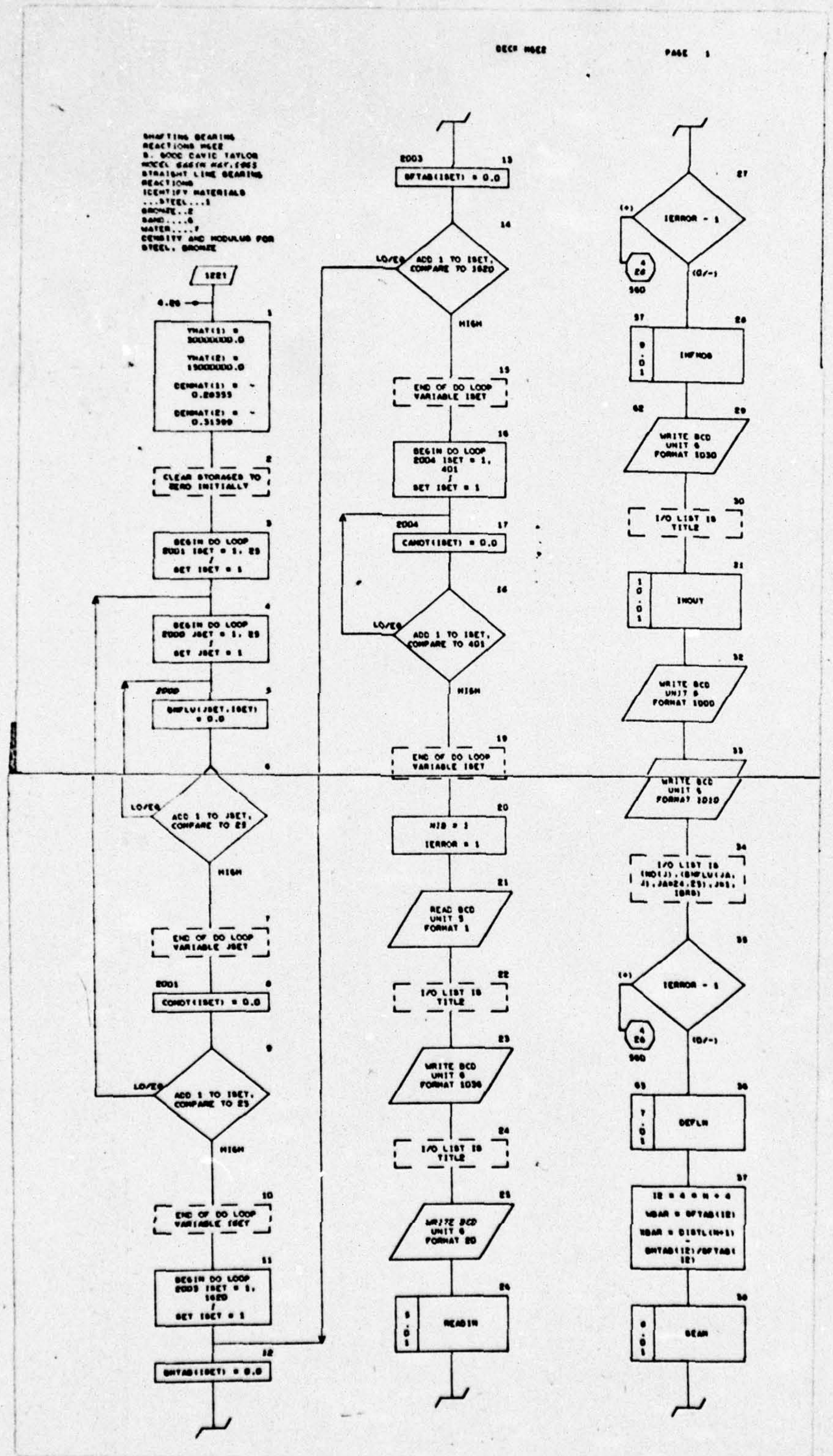
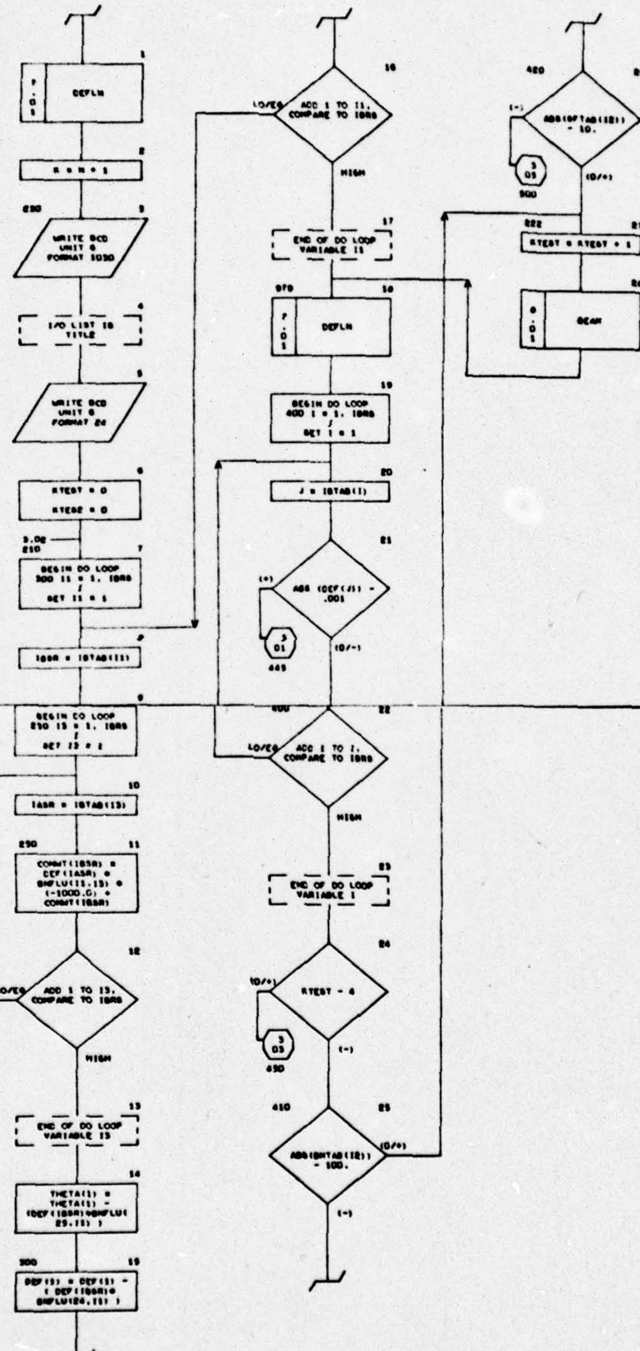


Figure A.2 - Sample Graphic Output

FLOW CHART




DEFLN
WRITE BCD UNIT 6 FORMAT 1030
I/O LIST IS TITLE
WRITE BCD UNIT 6 FORMAT 24
BEGIN DO LOOP
END OF DO LOOP VARIABLE I3
ADD 1 TO I3, COMPARE TO IBRG
HIGH
ADD 1 TO I1, COMPARE TO IBRG
END OF DO LOOP VARIABLE I1
DEFLN
J = IBTAB(I)
ADD 1 TO I, COMPARE TO IBRG
END OF DO LOOP VARIABLE I
BEAM

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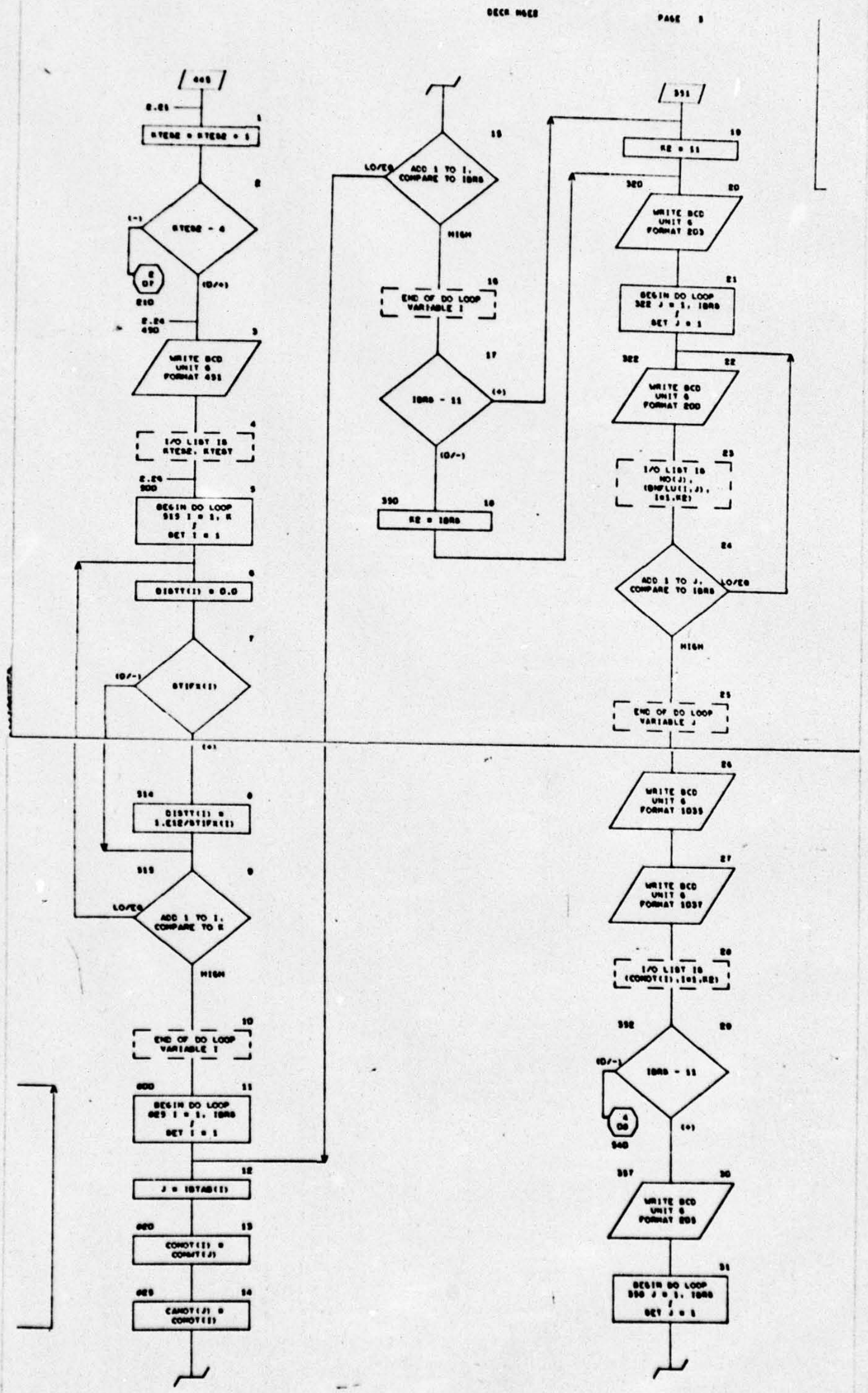

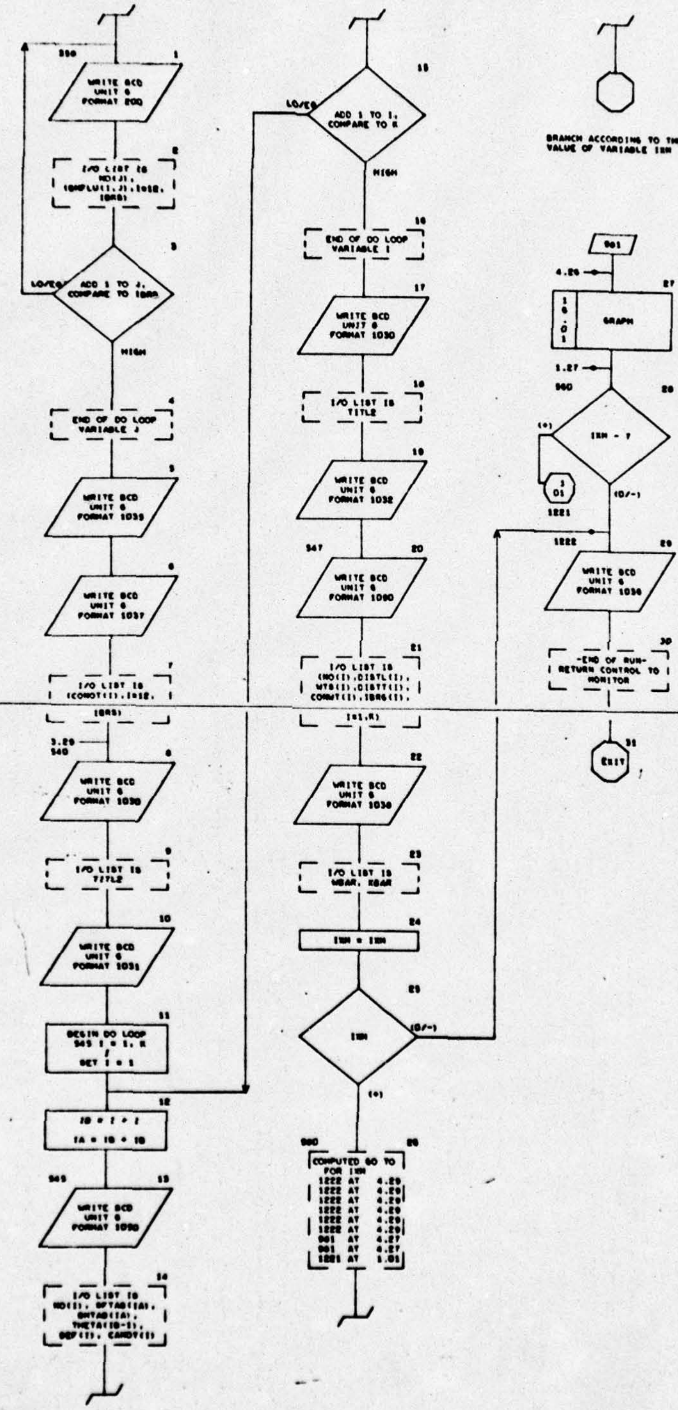
WRITE BCD UNIT 6 FORMAT 200
I/O LIST IS
END OF DO LOOP VARIABLE J
WRITE BCD UNIT 6 FORMAT 1035
WRITE BCD UNIT 6 FORMAT 1037
WRITE BCD UNIT 6 FORMAT 1030
WRITE BCD UNIT 6 FORMAT 1031
BEGIN DO LOOP
WRITE BCD UNIT 6 FORMAT 1090
ADD 1 TO I, COMPARE TO K
HIGH
END OF DO LOOP VARIABLE I
WRITE BCD UNIT 6 FORMAT 1030
I/O LIST IS TITL2
WRITE BCD UNIT 6 FORMAT 1032
WRITE BCD UNIT 6 FORMAT 1090
WRITE BCD UNIT 6 FORMAT 1030
COMPUTED GO TO
BRANCH ACCORDING TO THE VALUE OF VARIABLE IXM
GRAPH
WRITE BCD UNIT 6 FORMAT 1036
-END OF RUN- RETURN CONTROL TO MONITOR
EXIT

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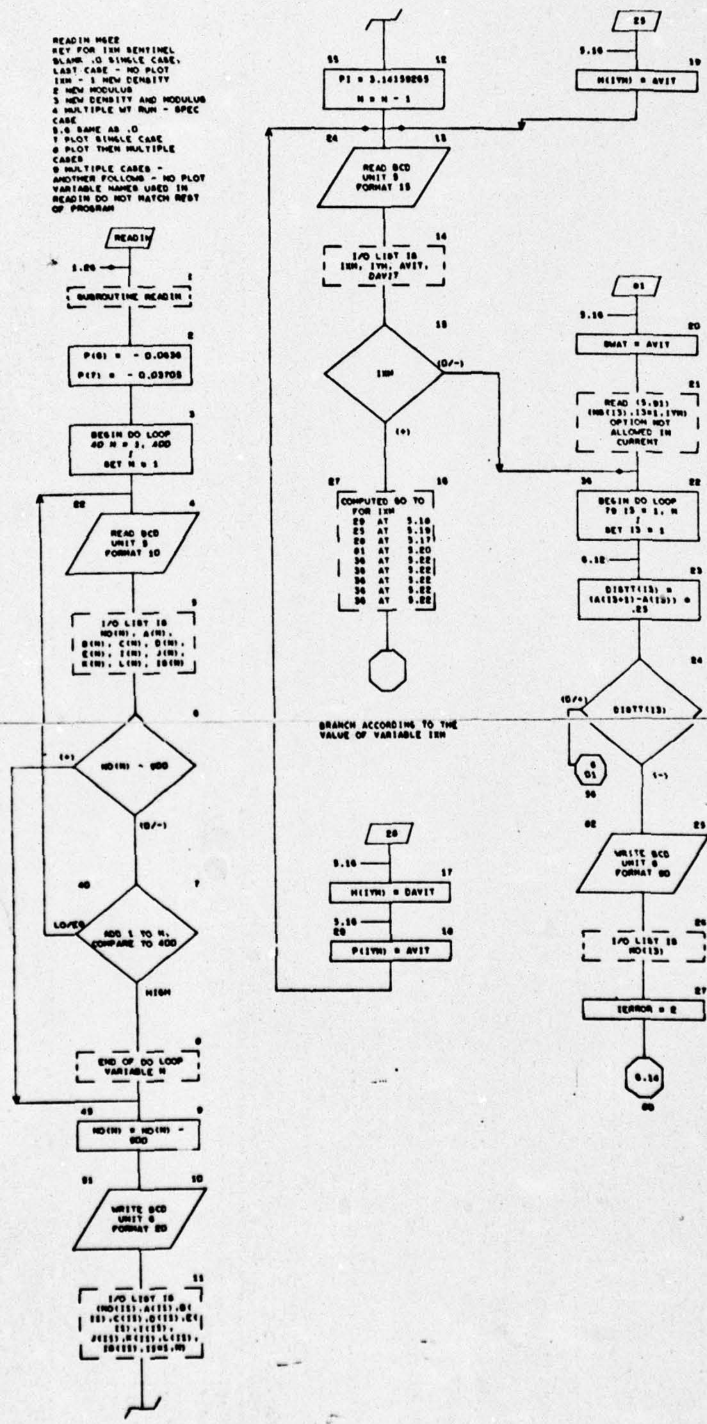
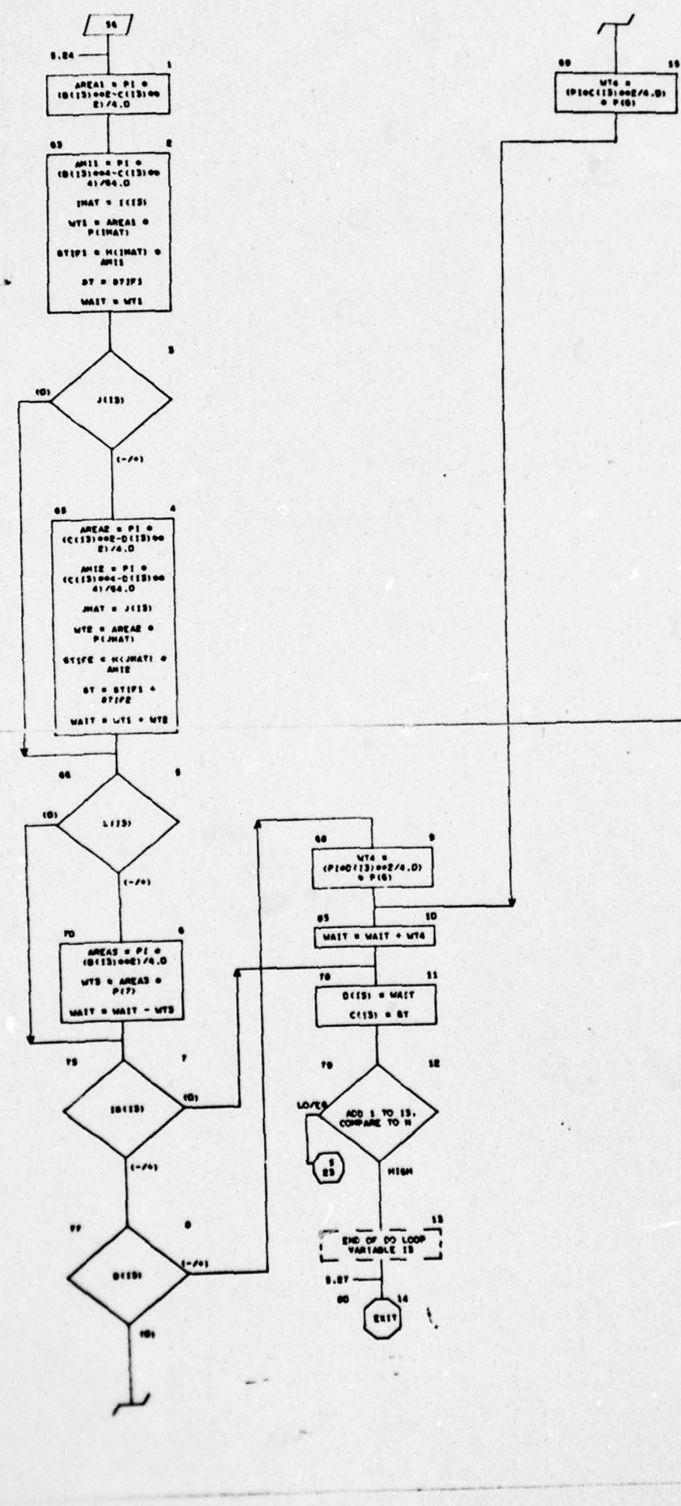
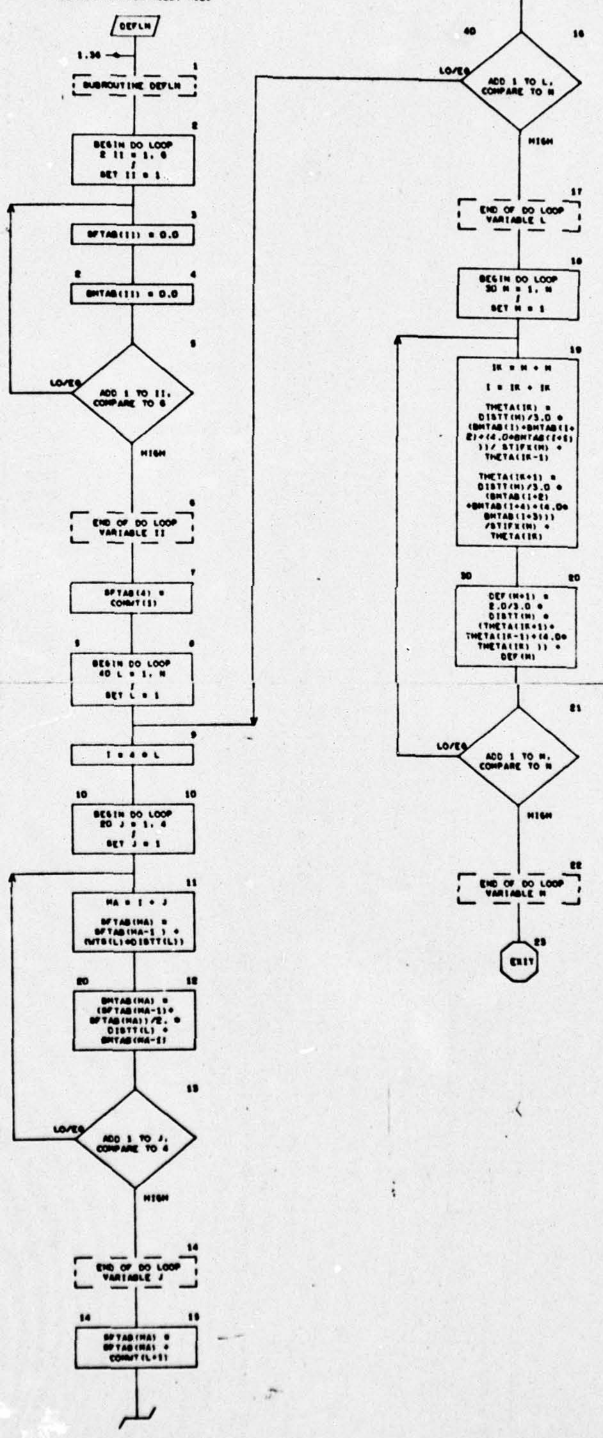
SUBROUTINE READIN

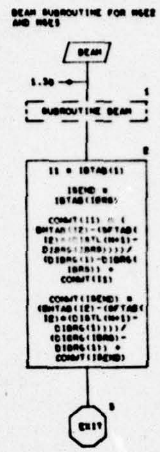
READIN USES
KEY FOR IXM SENTINEL
BLANK .0 SINGLE CASE,
LAST CASE - NO PLOT
IXM - 1 NEW DENSITY
2 NEW MODULUS
3 NEW DENSITY AND MODULUS
4 MULTIPLE WT RUN - SPEC
CASE
5,6 SAME AS .0
7 PLOT SINGLE CASE
8 PLOT THEN MULTIPLE
CASES
9 MULTIPLE CASES -
ANOTHER FOLLOWS - NO PLOT
VARIABLE NAMES USED IN
READIN DO NOT MATCH REST
OF PROGRAM

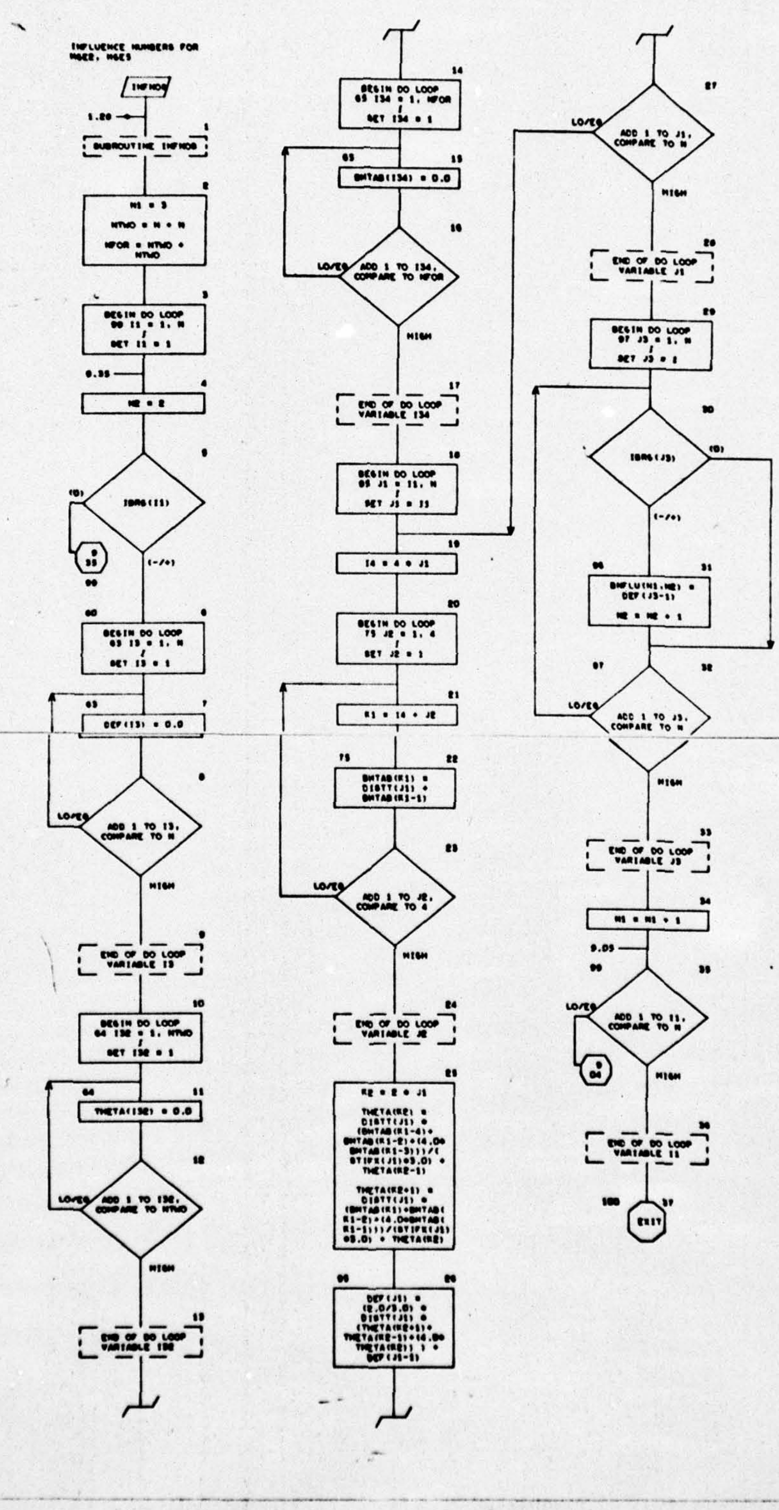



S4
5.24
AREA1 = PI * (B(I3)**2-C(I3)** 2)/4.0
AMI1 = PI * (B(I3)**4-C(I3)** 4)/64.0
IMAT = I(I3)
WT1 = AREA1 * P(IMAT)
STIF1 = H(IMAT) * AMI1
ST = STIF1
WAIT = WT1
J(I3)
(0)
(-/+)
AREA2 = PI * (C(I3)**2-D(I3)** 2)/4.0
AMI2 = PI * (C(I3)**4-D(I3)** 4)/64.0
JMAT = J(I3)
WT2 = AREA2 * P(JMAT)
STIF2 = H(JMAT) * AMI2
ST = STIF1 + STIF2
WAIT = WT1 + WT2
L(I3)
AREA3 = PI * (B(I3)**2)/4.0
WT3 = AREA3 * P(7)
WAIT = WAIT - WT3
IB(I3)
B(I3)
WT4 = (PI*C(I3)**2/4.0) * P(6)
WT4 = (PI*D(I3)**2/4.0) * P(6)
WAIT = WAIT + WT4
D(I3) = WAIT
C(I3) = ST
ADD 1 TO I3, COMPARE TO N
LO/EQ
HIGH
END OF DO LOOP VARIABLE I3
5.27
EXIT

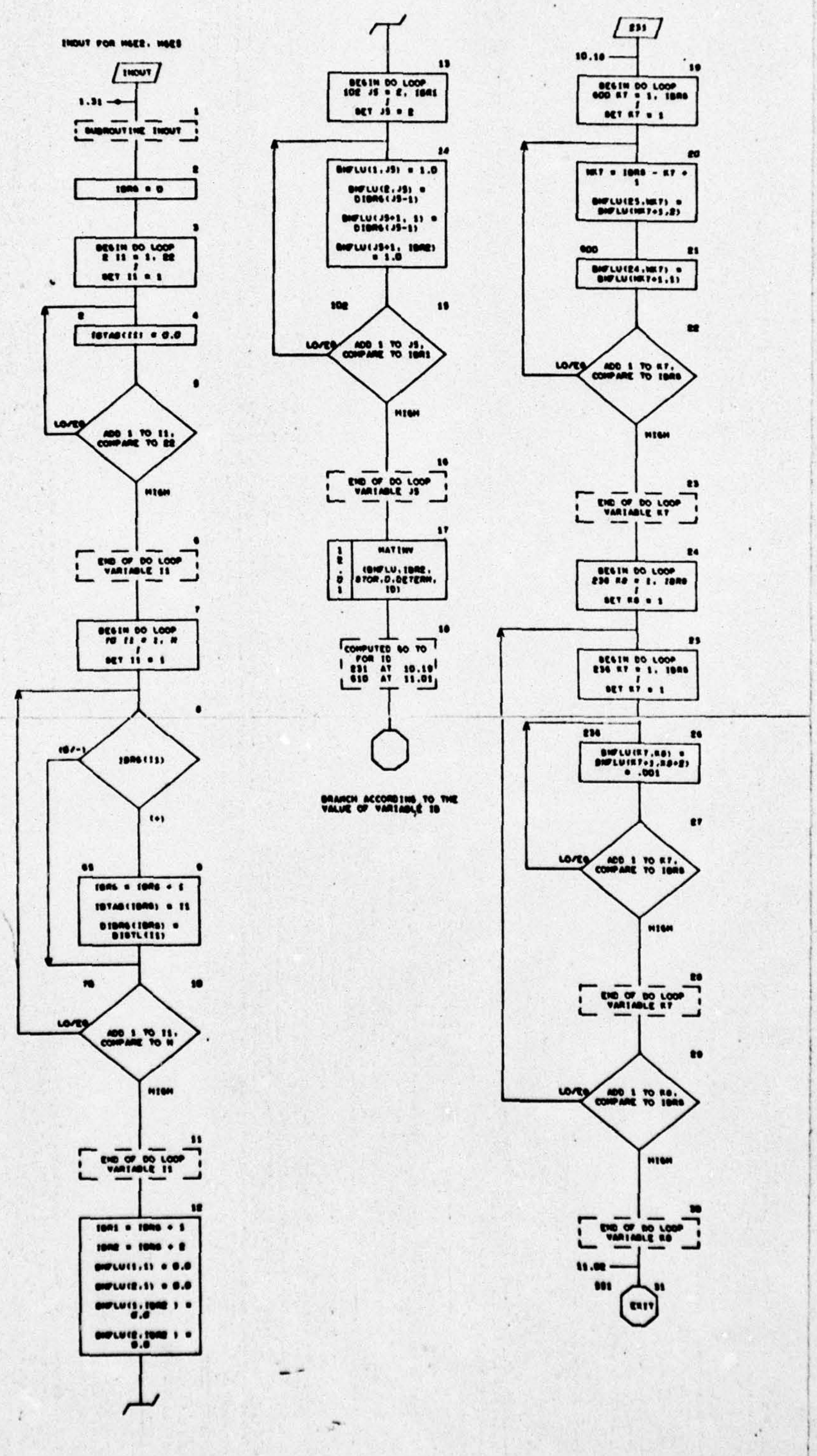
DEFLECTION FOR MGE2, MGE3




BEAM SUBROUTINE FOR NGE2 AND NGE3
BEAM
1.30
1
SUBROUTINE BEAM
2
I1 = IBTAB(1)
IBEND = IBTAB(IBRG)
COMWT(I1) = ((BMTAB(I2)-(BFTAB(I2)*(DISTL(N+1)-DIBRG(IBRG))))/(DIBRG(1)-DIBRG(IBRG)) + COMWT(I1)
COMWT(IBEND) = (BMTAB(I2)-(BFTAB(I2)*(DISTL(N+1)-DIBRG(1))))/(DIBRG(IBRG)-DIBRG(1)) + COMWT(IBEND)
3
EXIT

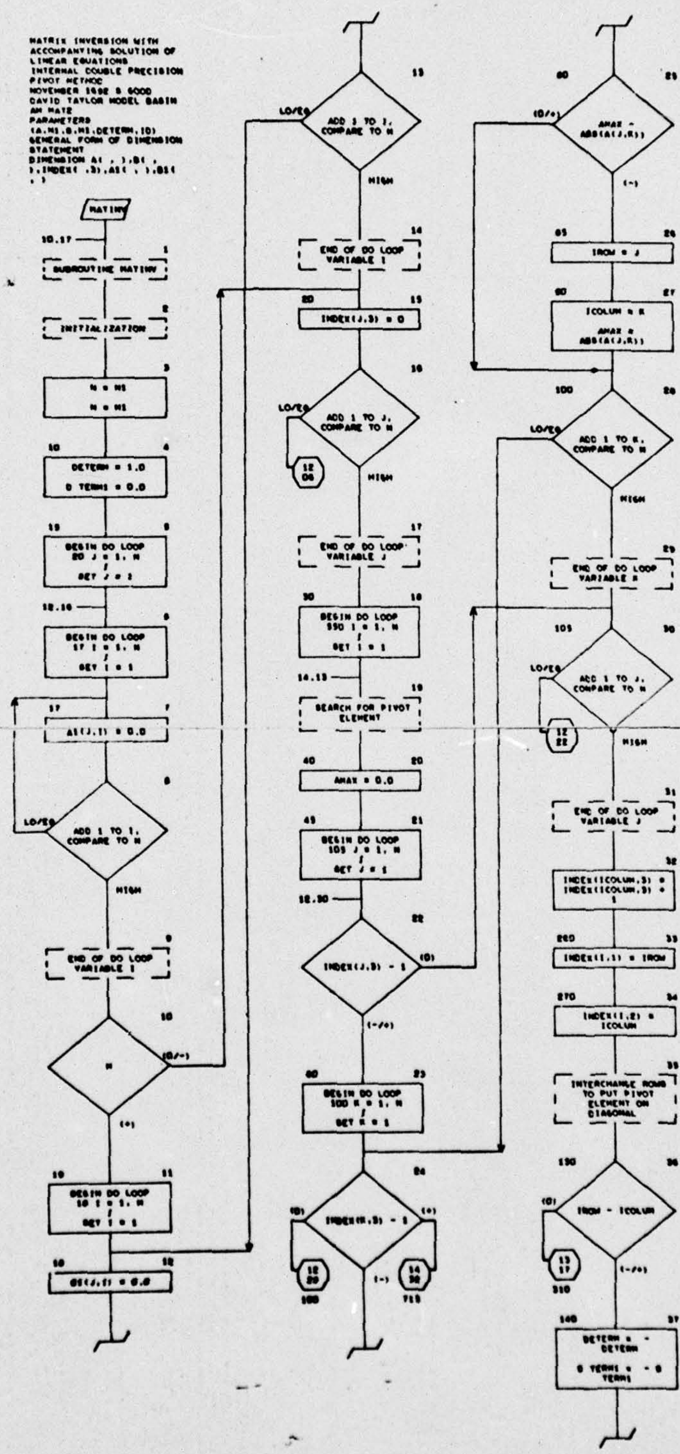


INFLUENCE NUMBERS FOR NGE2, NGE3
INFNOS
SUBROUTINE INFNOS
N1 = 3
NTWO = N + N
NFOR = NTWO + NTWO
BEGIN DO LOOP 99 I1 = 1, N / SET I1 = 1
N2 = 2
IDRG(I1)
BEGIN DO LOOP 63 I3 = 1, N / SET I3 = 1
DEF(I3) = 0.0
ADD 1 TO I3, COMPARE TO N
END OF DO LOOP VARIABLE I3
BEGIN DO LOOP 64 I32 = 1, NTWO / SET I32 = 1
THETA(I32) = 0.0
ADD 1 TO I32, COMPARE TO NTWO
END OF DO LOOP VARIABLE I32
BEGIN DO LOOP 65 I34 = 1, NFOR / SET I34 = 1
BMTAB(I34) = 0.0
ADD 1 TO I34, COMPARE TO NFOR
END OF DO LOOP VARIABLE I34
BEGIN DO LOOP 95 J1 = I1, N / SET J1 = I1
I4 = 4 * J1
BEGIN DO LOOP 75 J2 = 1, 4 / SET J2 = 1
K1 = I4 + J2
ADD 1 TO J2, COMPARE TO 4
END OF DO LOOP VARIABLE J2
ADD 1 TO J1, COMPARE TO N
END OF DO LOOP VARIABLE J1
BEGIN DO LOOP 97 J3 = 1, N / SET J3 = 1
IDRG(J3)
N2 = N2 + 1
ADD 1 TO J3, COMPARE TO N
END OF DO LOOP VARIABLE J3
N1 = N1 + 1
ADD 1 TO I1, COMPARE TO N
END OF DO LOOP VARIABLE I1
EXIT
LO/EQ
HIGH


INOUT FOR HGE2, HGE3
INOUT
SUBROUTINE INOUT
BEGIN DO LOOP
SET I1 = 1
ADD 1 TO I1, COMPARE TO 22
LO/EQ
HIGH
END OF DO LOOP VARIABLE I1
BEGIN DO LOOP 102 JS = 2, IBR1
SET JS = 2
ADD 1 TO JS, COMPARE TO IBR1
END OF DO LOOP VARIABLE JS
MATINV
COMPUTED GO TO
BRANCH ACCORDING TO THE VALUE OF VARIABLE ID
BEGIN DO LOOP
SET K7 = 1
ADD 1 TO K7, COMPARE TO IBR6
END OF DO LOOP VARIABLE K7
ADD 1 TO K8, COMPARE TO IBR6
END OF DO LOOP VARIABLE K8
EXIT

ERROR SET FOR SINGULAR ARRY

MATRIX INVERSION WITH
ACCOMPANYING SOLUTION OF
LINEAR EQUATIONS
INTERNAL DOUBLE PRECISION
PIVOT METHOD
NOVEMBER 1962 S GOOD
DAVID TAYLOR MODEL BASIN
AM MAT2
PARAMETERS
(A,N1,B,M1,DETERM,ID)
GENERAL FORM OF DIMENSION
STATEMENT
DIMENSION A(,),B(,
),INDEX(,3),A1(,),B1(
,)



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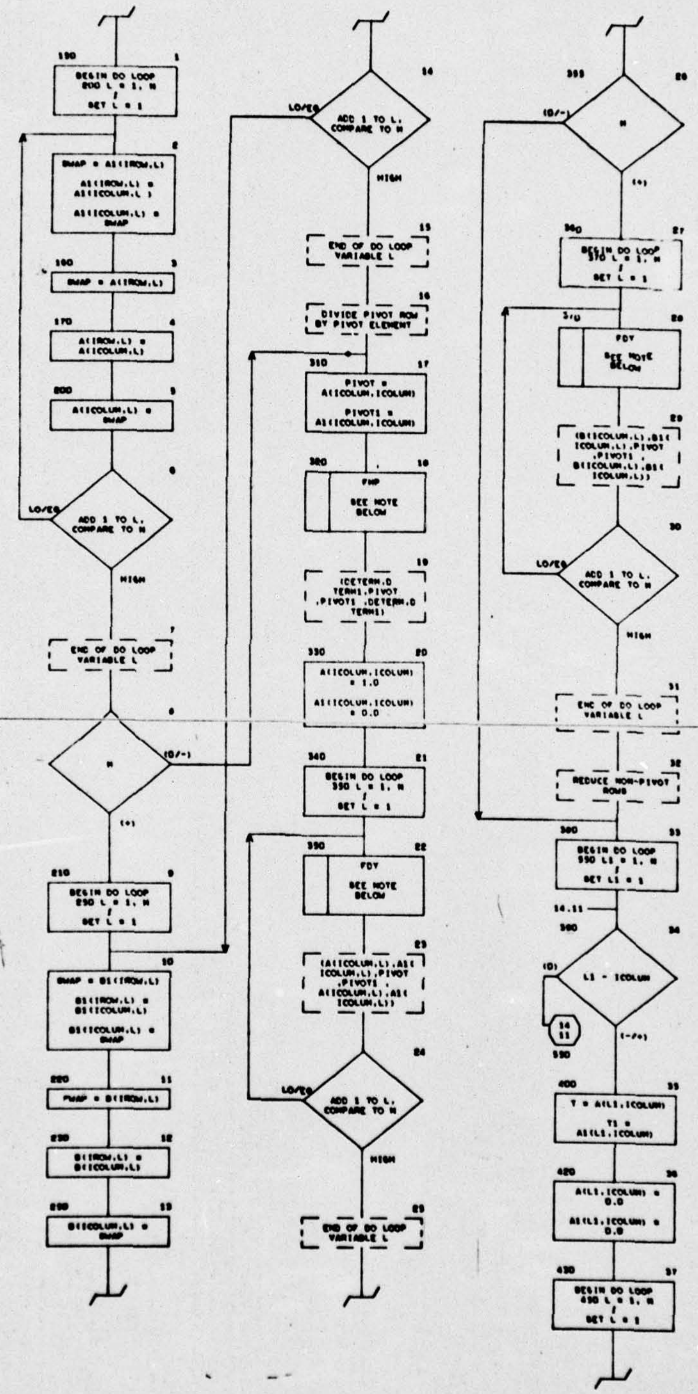
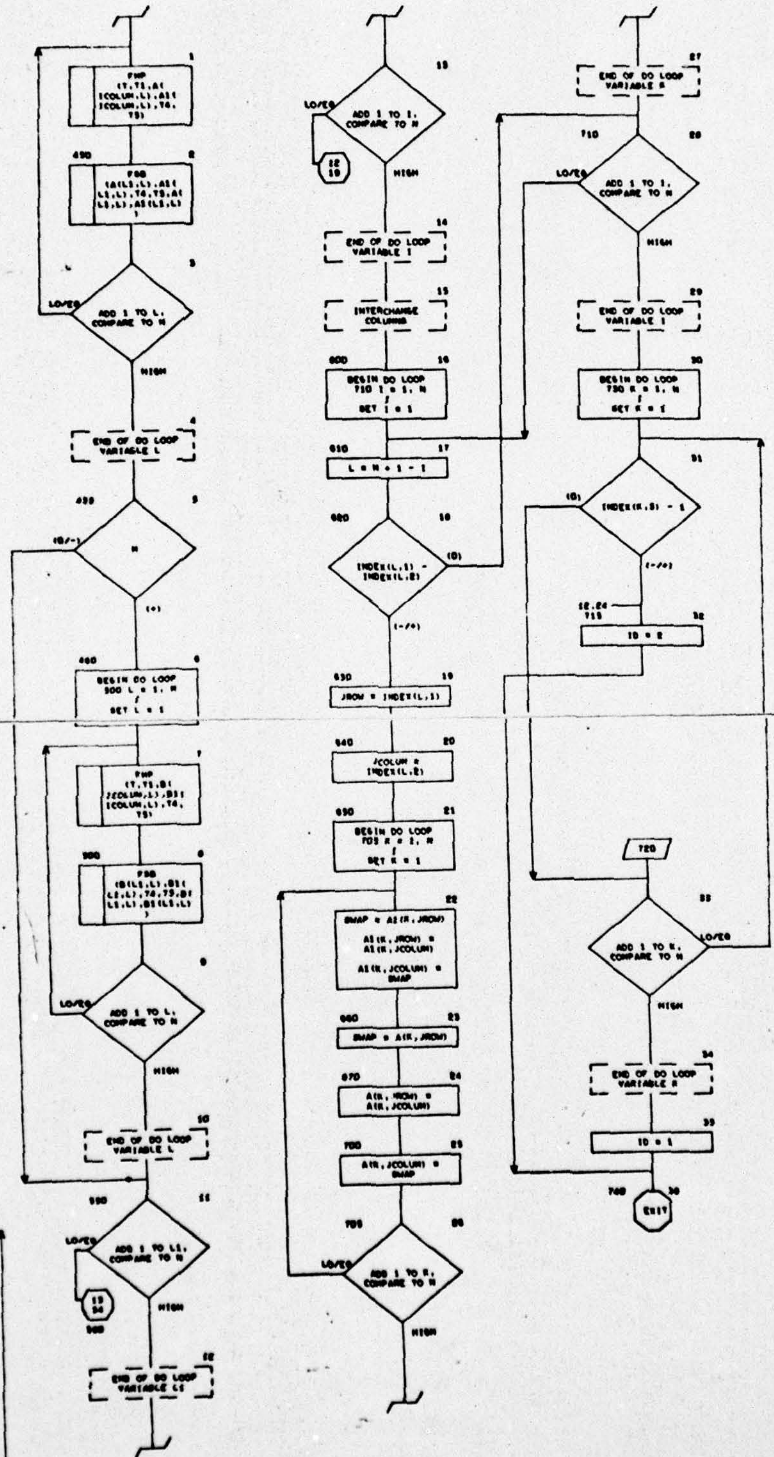
SUBROUTINE MATINV DECK MATB PAGE 13





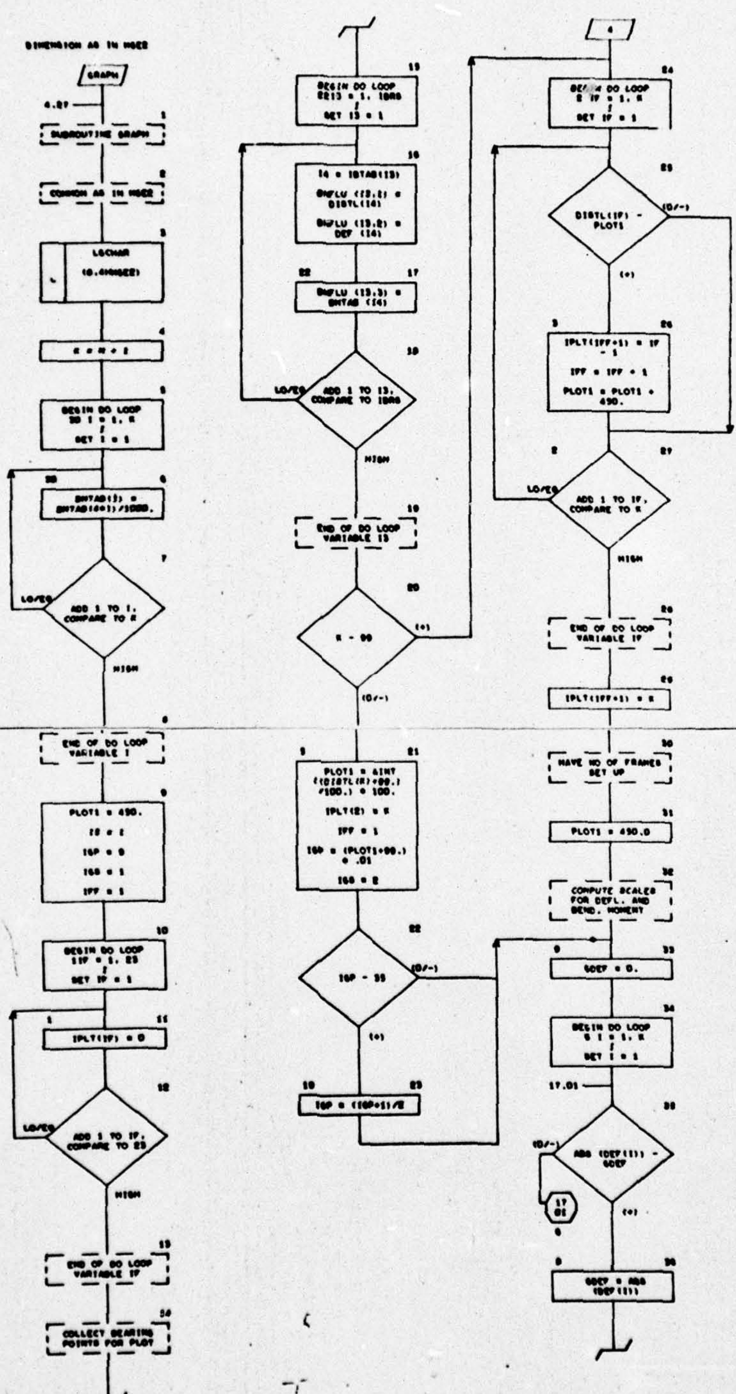
LAST CARD OF PROGRAM

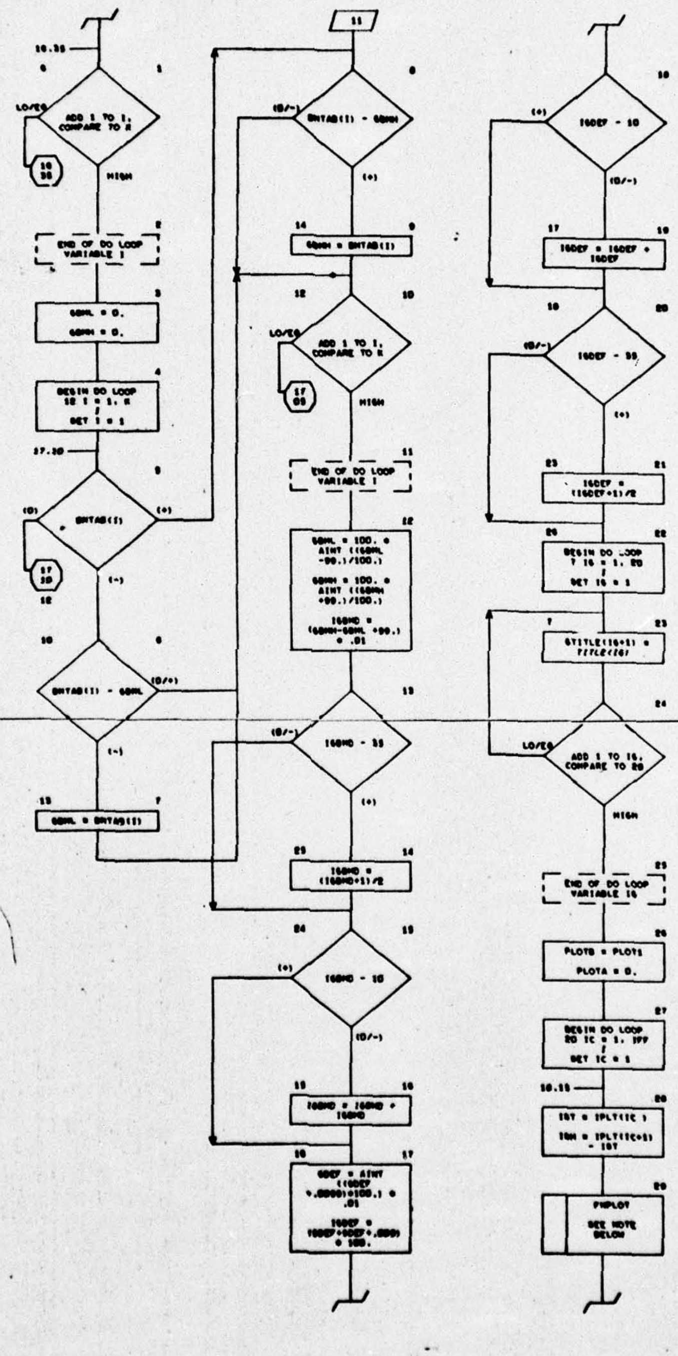
SUBROUTINE GRAPH

DECK GRAPHS

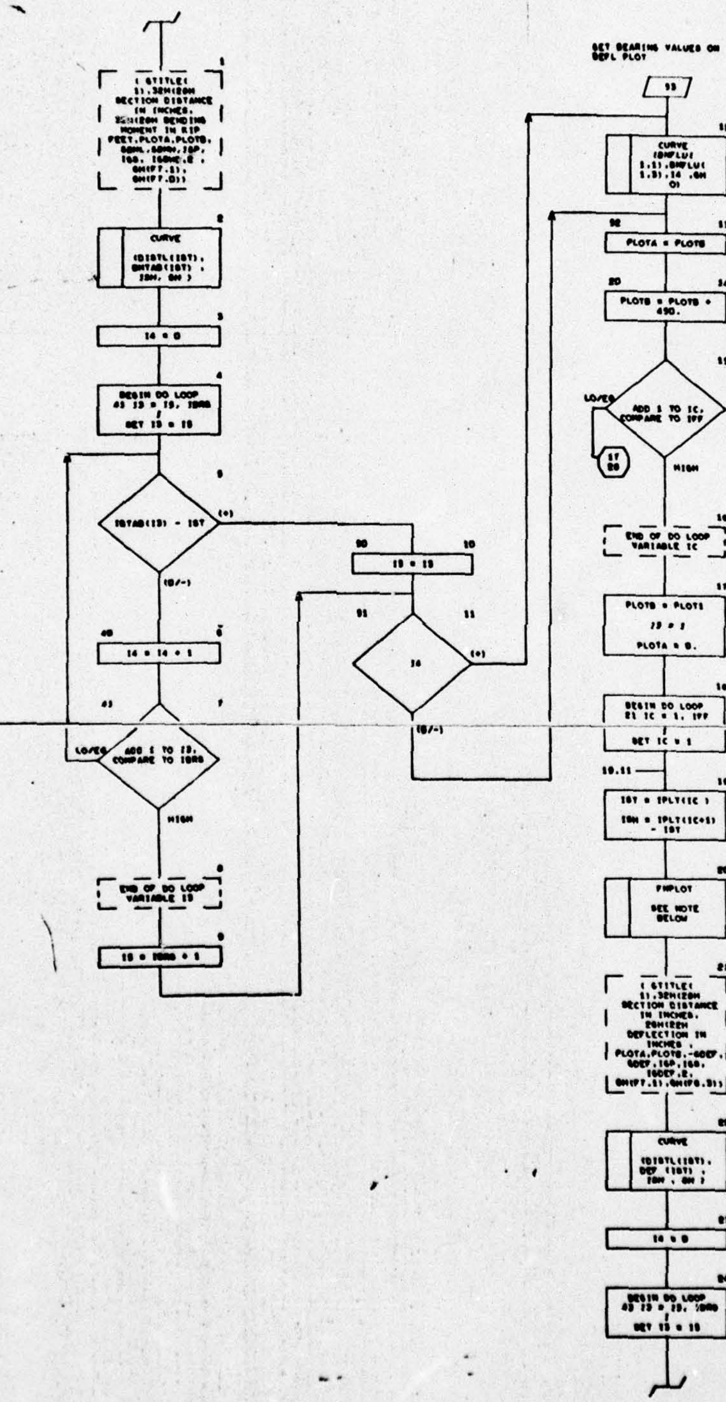
PAGE 16

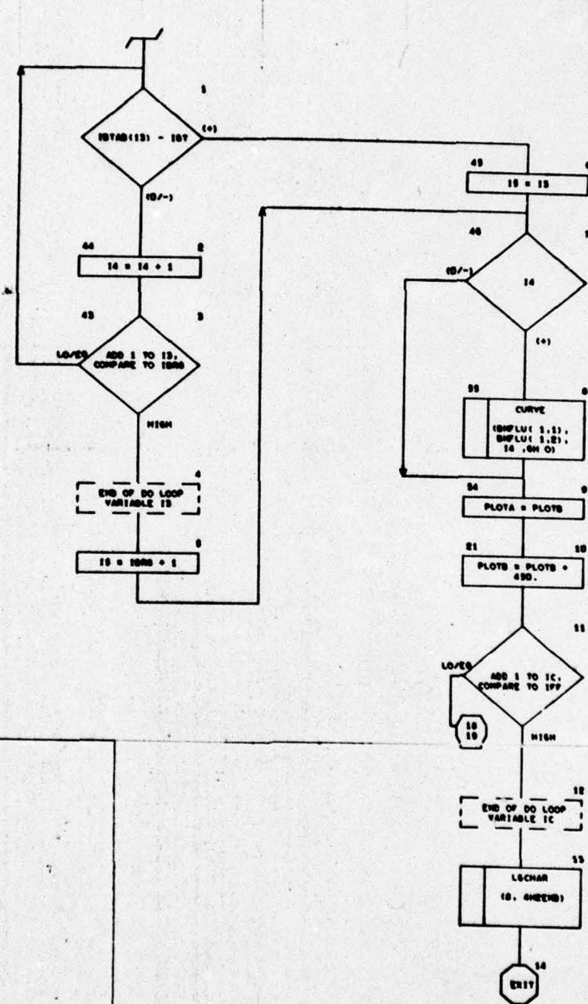
DIMENSION AS IN MSE2





ADD 1 TO I, COMPARE TO K
LO/EQ
HIGH
END OF DO LOOP VARIABLE I
BEGIN DO LOOP
(+)
(-)
(0/-)
(0/+)
END OF DO LOOP VARIABLE I
ADD 1 TO I, COMPARE TO K
LO/EQ
HIGH
ADD 1 TO I6, COMPARE TO 20
END OF DO LOOP VARIABLE I6
PLOTB = PLOT1
PLOTA = 0.
BEGIN DO LOOP
SET IC = 1
SEE NOTE BELOW

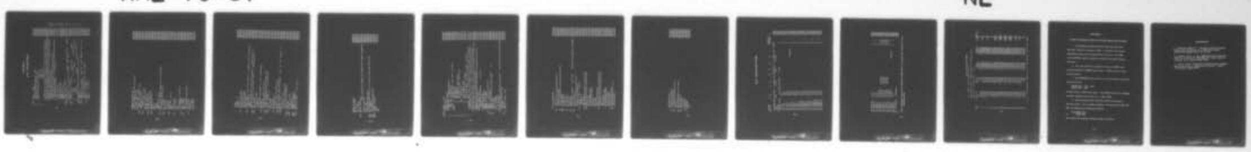

SET BEARING VALUES ON
DEFL PLOT
CURVE
(DISTL(IST),
BMTAB(IST) ,
ISN, 6H)
BEGIN DO LOOP
SET IS = IS
ADD 1 TO IS,
COMPARE TO IBRG
LO/EQ
HIGH
END OF DO LOOP
VARIABLE IS
PLOTA = PLOTB
ADD 1 TO IC,
COMPARE TO IPF
END OF DO LOOP
VARIABLE IC
PLOTA = 0.
BEGIN DO LOOP
SET IC = 1
FMPLOT
SEE NOTE
BELOW
SECTION DISTANCE
IN INCHES,
DEFLECTION IN
INCHES ,
CURVE
(DISTL(IST),
DEF (IST) ,
ISN , 6H)


(+)
(0/-)
I4 = I4 + 1
LO/EQ
HIGH
END OF DO LOOP VARIABLE I3
(0/-)
I4
(+)
CURVE
PLOTA = PLOTB
PLOTB = PLOTB + 490.
LO/EQ
ADD 1 TO IC, COMPARE TO IFF
HIGH
END OF DO LOOP VARIABLE IC
LGCHAR
EXIT

AD-A041 797   NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER BETHESDA --ETC F/G 13/10
SHIP PROPULSION SHAFTING BEARING REACTION PROGRAMS MGE2 AND MGE--ETC(U)
AUG 67 S E GOOD

UNCLASSIFIED   AML-70-67   NL

2 OF 2
ADA
041797



END

DATE
FILMED
8-77

APPENDIX B

MGE5 - PROGRAM LISTING

```
$IBFTC MGE5     DECK                                                    MGE50001
C       SHAFTING BEARING REACTIONS  MGE5                                MGE50002
C       BEARINGS NOT ON STRAIGHT LINE                                   MGE50003
C       IDENTIFY MATFRIALS ...STEEL...1                                 MGE50004
C                             BRONZE..2                                 MGE50005
C                             SAND....6                                 MGE50006
C                             WATER....7                                MGE50007
        DIMENSION DISTL(401),DIA(401),STIFX(401),WTS(401),CONWT(401),  MGE50008
       1IM(401),JM(401),IBRG(401),IWATR(401),IS(401),YMAT(7),DENMAT(7), MGE50009
       2DISTT(401), BMTAB(1620),THETA(802),DEF(401),BNFLU(25,25),DIBRG(25)MGE50010
       3,IBTAB(25), SFTAB(1620),TITL2(12) ,TITL5(12),XBRG(25) ,NO(400)  MGE50011
        DIMENSION CANOT(401),CONOT(25)                                  MGE50012
        COMMON N,NO,DISTL,DIA,STIFX,WTS,CONWT,IM,JM,IBRG,               MGE50013
       1 IWATR,IS,YMAT,DENMAT,DISTT,BMTAB,THETA,DEF,BNFLU,DIBRG,IBTAB,  MGE50014
       2  IBRS,SFTAB,I2,IERROR,       TITL2,IXM                         MGE50015
        DIMENSION NS(50)                                                MGE50016
        COMMON SWAT,NS,IYM                                              MGE50017
        COMMON TITL5,XBRG                                               MGE50018
    1   FORMAT(12A6)                                                    MGE50019
  2     FORMAT(I1, 5F11.8)                                              MGE50020
 1030   FORMAT(1H120X,12A6///)                                          MGE50021
 1032   FORMAT(110H0              *    WITH  CERTAIN  BEARINGS  LOWERED OMGE50022
       1R  RAISED  FROM  ORIGINAL  STRAIGHT  LINE  DATUM               )MGE50023
 1037   FORMAT(F14.1,10F10.1     )                                      MGE50024
 1040   FORMAT(110H     STATION        SHEAR FORCE          MOMENT      MGE50025
       1        SLOPE            DEFLECTION          BEARING  /         MGE50026
       2        113H       NO.           (KIP.)             (KIP.INCH)  MGE50027
       1     (RADIANS)           (INCH)          REACTION (LBS.)      ) MGE50028
 1050   FORMAT(I9,-3PF21.5,F19.3,0PF20.7,F20.7,F16.1 )                  MGE50029
 1097   FORMAT(I1)                                                      MGE50030
 1036   FORMAT(1H1 20X 45H ***   SHAFTING  SYSTEM  PROGRAM  MGE5  ***   MGE50031
       1////20X,12A6/20X12A6)                                           MGE50032
C        DENSITY AND MODULUS FOR STEEL, BRONZE                          MGE50033
 1221   YMAT(1)=30000000.0                                              MGE50034
        YMAT(2)=    15000000.0                                          MGE50035
        DENMAT(1)=-0.28355                                              MGE50036
```

```
      DENMAT(2)=-0.31399                                                MGE50037
C     CLEAR STORAGES TO ZERO INITIALLY                                  MGE50038
      DO 2001 ISET=1,25                                                 MGE50039
      DO 2000 JSET = 1,25                                               MGE50040
 2000   BNFLU(JSET,ISET) = 0.0                                          MGE50041
      XBRG(ISET) = 0.0                                                  MGE50042
 2001    CONOT(ISET) = 0.0                                              MGE50043
      DO 2003 ISET=1,1620                                               MGE50044
      BMTAB(ISET)=0.0                                                   MGE50045
 2003 SFTAB(ISET)=0.0                                                   MGE50046
      DO 2004 ISET=1,401                                                MGE50047
 2004 CANOT(ISET)=0.0                                                   MGE50048
      N76 =5                                                            MGE50049
      N77=1                                                             MGE50050
      IERROR = 1                                                        MGE50051
      READ (5,1) TITL5                                                  MGE50052
 231  READ (5,2) IMOVE, (XBRG(I77),I77=N77,N76)                         MGE50053
      IF (IMOVE) 220,230,220                                            MGE50054
 230  N76 =N76+5                                                        MGE50055
      N77=N77+5                                                         MGE50056
      GO TO 231                                                         MGE50057
 220  CONTINUE                                                          MGE50058
      READ (5,1) TITL2                                                  MGE50059
      NIB=1                                                             MGE50060
 50   CALL READIN                                                       MGE50061
      IXM = IXM                                                         MGE50062
      N=N                                                               MGE50063
      IF(IERROR-1) 57,57,560                                            MGE50064
  57  CALL INFNOS                                                       MGE50065
 63   CALL INOUT                                                        MGE50066
      IBRS = IBRS                                                       MGE50067
      IF(IERROR-1) 65,65,560                                            MGE50068
  65  CALL DEFLN                                                        MGE50069
      I2=4*N+4                                                          MGE50070
       CALL BEAM                                                        MGE50071
      CALL DEFLN                                                        MGE50072
```

```
      K=N+1                                                             MGE50073
       KTEST = 0                                                        MGE50074
      KTES2=0                                                           MGE50075
  210 DO 300 I1=1,IBRS                                                  MGE50076
      IBSR=IBTAB(I1)                                                    MGE50077
      DO 250 I3=1,IBRS                                                  MGE50078
      IASR=IBTAB(I3)                                                    MGE50079
  250 CONWT(IBSR) = (DEF(IASR)-XBRG(I3  ))*BNFLU(I1,I3)*(-1000.0)+      MGE50080
     1 CONWT(IBSR)                                                      MGE50081
      THETA(1)= THETA(1)-((DEF(IBSR)-XBRG(I1  ))*BNFLU(25,I1) )         MGE50082
  300 DEF(1) =DEF(1)-((DEF(IBSR)- XBRG(I1  ))*BNFLU(24,I1) )            MGE50083
  979 CALL DEFLN                                                        MGE50084
      DO 400 I=1,IBRS                                                   MGE50085
      J=IBTAB(I)                                                        MGE50086
      IF(ABS (DEF(J)-XBRG(I))-.001) 400,400,445                         MGE50087
  400 CONTINUE                                                          MGE50088
      IF(KTEST-4) 410, 450, 450                                         MGE50089
  410 IF(ABS (BMTAB(I2))-100.)420,222 ,222                              MGE50090
  420 IF(ABS (SFTAB(I2))- 10.)500,222,222                               MGE50091
  222 KTEST = KTEST +1                                                  MGE50092
      CALL BEAM                                                         MGE50093
      GO TO 979                                                         MGE50094
  445 KTES2=KTES2+1                                                     MGE50095
      IF (KTES2-4) 210, 450, 450                                        MGE50096
  450 WRITE (6,451)    KTES2, KTEST                                     MGE50097
  451 FORMAT(27HOTOO MANY ITERATIONS - DEFL  I4,  9H  MOMENT  I4)       MGE50098
  500 DO 515 I=1,K                                                      MGE50099
      DISTT(I)=   0.0                                                   MGE50100
      IF (STIFX(I))515,515,514                                          MGE50101
  514 DISTT(I)=1.E12/STIFX(I)                                           MGE50102
  515 CONTINUE                                                          MGE50103
  800 DO 825 I=1,IBRS                                                   MGE50104
      J=IBTAB(I)                                                        MGE50105
  820 CONOT(I)=CONWT(J)                                                 MGE50106
  825 CANOT(J)=CONOT(I)                                                 MGE50107
  540 WRITE (6,1036)    TITL5,TITL2                                     MGE50108
```

```
      WRITE (6,1040)                                                      MGE50109
      DO 545 I=1,K                                                        MGE50110
      IB = I+I                                                            MGE50111
      IA = IB+IB                                                          MGE50112
  545 WRITE (6,1050)                                                      MGE50113
     1             NO(I),SFTAB(IA),BMTAB(IA),THETA(IB-1),DEF(I),CANOT(I)  MGE50114
      WRITE (6,1032)                                                      MGE50115
      IXM = IXM                                                           MGE50116
      IF(IXM)1222,1222,980                                                MGE50117
  980 GO TO(1222,1222,1222,1222,1222,1222,981,981,1221),IXM               MGE50118
  981 CALL GRAPH                                                          MGE50119
  560 IF(IXM-7)1222,1222,1221                                             MGE50120
 1222  WRITE (6,1036)                                                     MGE50121
       STOP                                                               MGE50122
      END                                                                 MGE50123
```

```
$IBFTC RED5     DECK                                                    RED50002
C     READIN MGE5                                                       RED50003
      SUBROUTINE READIN                                                 RED50004
C     SECOND CASE   BEARING RAISED                                      RED50005
C        KEY FOR IXM SENTINEL                                           RED50006
C      BLANK   ,0  SINGLE CASE, LAST CASE - NO PLOT                     RED50007
C     IXM -  1    NEW DENSITY                                           RED50008
C            2    NEW MODULUS                                           RED50009
C            3    NEW DENSITY AND MODULUS                               RED50010
C            4    MULTIPLE WT RUN - SPEC CASE                           RED50011
C            5,6    SAME AS ,0                                          RED50012
C            7    PLOT SINGLE CASE                                      RED50013
C            8    PLOT THEN MULTIPLE CASES                              RED50014
C            9    MULTIPLE CASES - ANOTHER FOLLOWS - NO PLOT            RED50015
C      VARIABLE NAMES USED IN READIN DO NOT MATCH REST OF PROGRAM       RED50016
       DIMENSION A(401), B(401),C(401),D(401),E(401),I(401),J(401),    RED50017
     1K(401),L(401),IS(401),H(   7),P(   7),DISTT(401),BMTAB(1620),     RED50018
     2THETA(802),DEF(401),BNFLU(25,25),DIBRG(25),IBTAB(25),SFTAB(1620), RED50019
     3TITL2(12),TITL5(12),XBRG(25),NO(400)                              RED50020
      COMMON N,NO,A,B,C,D,E,I,J,K,L,IS,H,P,DISTT,BMTAB,THETA,DEF,       RED50021
     1BNFLU,DIBRG,IBTAB,                                                RED50022
     2  IBRS,SFTAB,I2,IERROR,       TITL2,IXM                           RED50023
      DIMENSION NS(50)                                                  RED50024
      COMMON SWAT,NS,IYM                                                RED50025
      COMMON TITL5,XBRG                                                 RED50026
   10 FORMAT(    I3,5F12.4,2I2,3I1)                                     RED50027
 15   FORMAT (2I2,2F12.2)                                               RED50028
  90   FORMAT(25H0 STATION DISTANCE ERROR      I5)                      RED50029
 91   FORMAT(24I3)                                                      RED50030
      P(6)=-0.0636                                                      RED50031
      P(7)=-0.03705                                                     RED50032
      DO 40 N=1,400                                                     RED50033
   22 READ(5,10)NO(N),A(N),B(N),C(N),D(N),E(N),I(N),J(N),K(N),L(N),IS(N)RED50034
      IF(NO(N)-900)40,40,45                                             RED50035
 40   CONTINUE                                                          RED50036
   45  NO(N) = NO(N) -900                                               RED50037
```

```
   55 PI=3.14159265                                                  RED50038
        N = N-1                                                      RED50039
 24     READ (5,15) IXM,IYM,AVIT,DAVIT                               RED50040
        IF(IXM) 36,36,27                                             RED50041
 27     GO TO (29,25,28,81,36,36,36,36,36),IXM                       RED50042
 28     H(IYM)=DAVIT                                                 RED50043
 29     P(IYM)=AVIT                                                  RED50044
        GO TO 24                                                     RED50045
 25     H(IYM)=AVIT                                                  RED50046
        GO TO 24                                                     RED50047
 81     SWAT=AVIT                                                    RED50048
C       READ (5,91) (NS(II), II=1,IYM)     OPTION NOT ALLOWED IN CURRENT  RED50049
 36     DO 79 I3=1,N                                                 RED50050
        DISTT(I3)=(A(I3+1)-A(I3))*.25                                RED50051
        IF(DISTT(I3))82,56,56                                        RED50052
   82    WRITE (6,90)     NO(I3)                                     RED50053
         IERROR = 2                                                  RED50054
         GO TO 80                                                    RED50055
   56 AREA1=PI*(B(I3)**2-C(I3)**2)/4.0                               RED50056
   63 AMI1=PI*(B(I3)**4-C(I3)**4)/64.0                               RED50057
      IMAT=I(I3)                                                     RED50058
      WT1=AREA1*P(IMAT)                                              RED50059
      STIF1=H(IMAT)*AMI1                                             RED50060
      ST=STIF1                                                       RED50061
      WAIT=WT1                                                       RED50062
      IF(J(I3))65,66,65                                              RED50063
   65 AREA2=PI*(C(I3)**2-D(I3)**2)/4.0                               RED50064
      AMI2=PI*(C(I3)**4-D(I3)**4)/64.0                               RED50065
      JMAT=J(I3)                                                     RED50066
      WT2=AREA2*P(JMAT)                                              RED50067
      STIF2=H(JMAT)*AMI2                                             RED50068
      ST=STIF1+STIF2                                                 RED50069
      WAIT=WT1+WT2                                                   RED50070
   66 IF(L(I3))70,75,70                                              RED50071
   70 AREA3=PI*(B(I3)**2)/4.0                                        RED50072
      WT3=AREA3*P(7)                                                 RED50073
```

```
      WAIT=WAIT-WT3                                                     RED50074
   75 IF(IS(I3))77,78,77                                                RED50075
  77  IF(D(I3))68,69,68                                                 RED50076
  69  WT4=(PI*C(I3)**2/4.0)*P(6)                                        RED50077
      GO TO 85                                                          RED50078
  68  WT4=(PI*D(I3)**2/4.0)*P(6)                                        RED50079
  85  WAIT=WAIT+WT4                                                     RED50080
   78 D(I3)=WAIT                                                        RED50081
      C(I3)=ST                                                          RED50082
   79 CONTINUE                                                          RED50083
   80 RETURN                                                            RED50084
      END                                                               RED50085
```

MGE5 - SAMPLE INPUT FORM

```
COLUMN         1  1       2   2       3    4     4     5          6666667  7
123 5          3  6       4   8       5    0     6     2          4567890  3

 RAISING BRGS 3,4,5,6  TO EQUALIZE OPERATING L.S. GEAR BRG. LOADS          TMGE
 .020         .020        .0787        .1018        .0726                  TMGE
9.0293                                                                     TMGE
 SAMPLE CASE     12 BEARING SHAFT     4/1/64                       1       TMGE
 01 0.0           8.0                                              3       TMGE
 02 2.0           8.0                                              3       TMGE
 03 4.0           18.0                                             3       TMGE
 04 12.5          18.0                                             1  1    TMGE
 05 24.0          36.0                                             1       TMGE
 06 40.5          36.0                                 -23100.0    1       TMGE
 07 57.25         18.0                                             1       TMGE
 08 68.5          18.0                                             3  1    TMGE
 09 93.5          33.0                                             3       TMGE
 10 98.5          18.0                                             3       TMGE
 11 109.5         17.5                                             3       TMGE
 12 122.75        31.0                                             3       TMGE
 13 130.25        17.0                                             3       TMGE
 14 306.5         17.0                                             1  1    TMGE
 15 540.5         17.0                                             3  1    TMGE
 16 590.75        31.0                                             3       TMGE
 17 598.25        17.0                                             3       TMGE
 18 774.5         17.0                                             1  1    TMGE
 19 1008.5        17.0                                             3  1    TMGE
 20 1058.75       31.0                                             3       TMGE
 21 1066.25       17.0                                             3       TMGE
 22 1242.5        17.0                                             1  1    TMGE
 23 1476.5        17.0                                             3  1    TMGE
 24 1526.75       31.0                                             3       TMGE
```

```
 25 1534.25     17.0                                               3        TMGE
 26 1698.50     17.0                                               1  1     TMGE
 27 1914.5      17.0                                               3  1     TMGE
 28 1968.5      34.0                                               3        TMGE
 29 2028.5      19.5625                                            3    1   TMGE
 30 2082.5      21.8125       19.5625                              2 3 1    TMGE
 31 2121.5      21.8125       19.5625                              2 111    TMGE
 32 2160.5      21.375        19.5625                              2 101    TMGE
 33 2371.0      21.8125       19.5625                              2 101    TMGE
 34 2443.0      21.8125       19.5625                              2 311    TMGE
 35 2515.0      19.5625                                            3   1    TMGE
 36 2543.5      19.5625                          -24343.0          3   1    TMGE
 37 2559.5      16.0                                               3   1    TMGE
938 2571.5                                                                  TMGE
 3 3 -0.28355    30000000.                                                  TMGE
07                                                                          TMGE
```

Note: Material 3 as used is identical to Material 1 to illustrate the insertion of new material cards.

MGE5 - SAMPLE OUTPUT SHEET

*** SHAFTING SYSTEM PROGRAM MGE5 ***

RAISING BRGS 3,4,5,6 TO EQUALIZE OPERATING L.S. GEAR BRG. LOADS

SAMPLE CASE 12 BEARING SHAFT 4/1/64 1

STATION NO.	SHEAR FORCE (KIP.)	MOMENT (KIP.INCH)	SLOPE (RADIANS)	DEFLECTION (INCH)	BEARING REACTION (LBS.)
1	-0.	0.	-0.0000114	0.0201429	0.
2	-0.02851	-0.029	-0.0000114	0.0201201	0.
3	-0.05701	-0.114	-0.0000114	0.0200973	0.
4	19.95398	-3.205	-0.0000115	0.0200000	20624.3
5	19.12420	221.494	-0.0000038	0.0198989	0.
6	-8.73801	497.755	-0.0000009	0.0198618	0.
7	-13.57237	310.906	0.0000019	0.0198725	0.
8	6.79524	153.651	0.0000189	0.0200000	21179.4
9	4.99137	300.983	0.0000562	0.0208893	0.
10	3.77877	322.909	0.0000571	0.0211727	0.
11	2.98507	360.110	0.0000815	0.0219327	0.
12	2.08139	393.675	0.0001177	0.0232491	0.
13	0.47629	403.266	0.0001199	0.0261406	0.
14	7.88510	-512.433	0.0002805	0.0786999	18782.3
15	8.83585	-429.372	-0.0000567	0.1017995	16011.0
16	5.60175	-68.628	-0.0001525	0.0959228	0.
17	3.99664	-30.634	-0.0001520	0.0947780	0.
18	7.73249	-325.870	-0.0001694	0.0725983	15089.8
19	8.71686	-278.522	-0.0001858	0.0292957	16084.7
20	5.48276	78.243	-0.0002210	0.0184674	0.
21	3.87765	113.345	-0.0002205	0.0168116	0.
22	6.98398	-202.864	-0.0000459	-0.0000087	14469.8
23	8.46648	-330.665	0.0000063	-0.0000157	16842.8
24	5.23238	13.519	-0.0000539	-0.0018265	0.
25	3.62727	46.742	-0.0000538	-0.0022306	0.
26	6.29193	-225.635	0.0000200	-0.0000253	13285.8
27	15.74768	-367.973	-0.0000618	-0.0000382	23387.6
28	12.27223	388.564	-0.0000504	-0.0046619	0.
29	-3.17422	661.504	-0.0000320	-0.0070765	0.
30	-7.17504	382.074	0.0001031	-0.0048424	0.
31	5.02968	30.504	0.0001341	-0.0000538	15083.9
32	1.35050	154.917	0.0001490	0.0064096	0.
33	-17.64255	-1559.821	-0.0001482	0.0297004	0.
34	35.02703	-3074.609	-0.0007453	-0.0000824	59461.9
35	28.23470	-797.186	-0.0012424	-0.0752218	0.
36	1.78015	-22.587	-0.0012959	-0.1116345	0.
37	0.59473	-3.588	-0.0012967	-0.1323769	0.
38	-0.00002	-0.019	-0.0012969	-0.1479388	0.

* WITH CERTAIN BEARINGS LOWERED OR RAISED FROM ORIGINAL STRAIGHT LINE DATUM

APPENDIX C

NOTES ON MODIFICATION FOR OTHER COMPUTER SYSTEMS

1. A programmed double-precision arithmetic was used internally in matrix inversion on 7090. A computer with greater significance might use a single-precision version, or the LARC version MAT2L might be modified to avoid the assembly language subroutine.

2. Use of SC 4020 option assumes a library of MAP coded routines available on NSRDC system tape. A FAP version of these routines exists.

3. For FORTRAN II use insert F on library and open subroutine names as follows:

MGE2 0104, 0108, 0109
MAT2 0040, 0037

A FAP version of DPAF also exists. Card MGE2 0159 may be changed to reflect standard system stop; e.g., CALL EXIT.

4. Total allowed number of stations (400) would handle an aircraft carrier. For a smaller computer, all dimensions of 400, 401 802, and 1620 may be reduced equivalently.

Card RED2 0032
or RED5 0032

must reflect the maximum allowed number of stations.

REFERENCES

1. Antkowiak, Edward T., "Calculation of Ship Propulsion Shafting Bearing Reactions on an IBM 650 Computer," Boston Naval Shipyard Report R-11 (1967).

2. Anderson, H. C., et. al., "Shafting Systems Programs MGE-402 and MGE-405," DR59MSD-202, General Electric Company, Lynn, Massachusetts (1959).

3. Luvisi, Joseph, "Calculation of Ship Propulsion Shafting Bearing Reactions on a Datatron 205 Computer," Boston Naval Shipyard Report R-24.

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